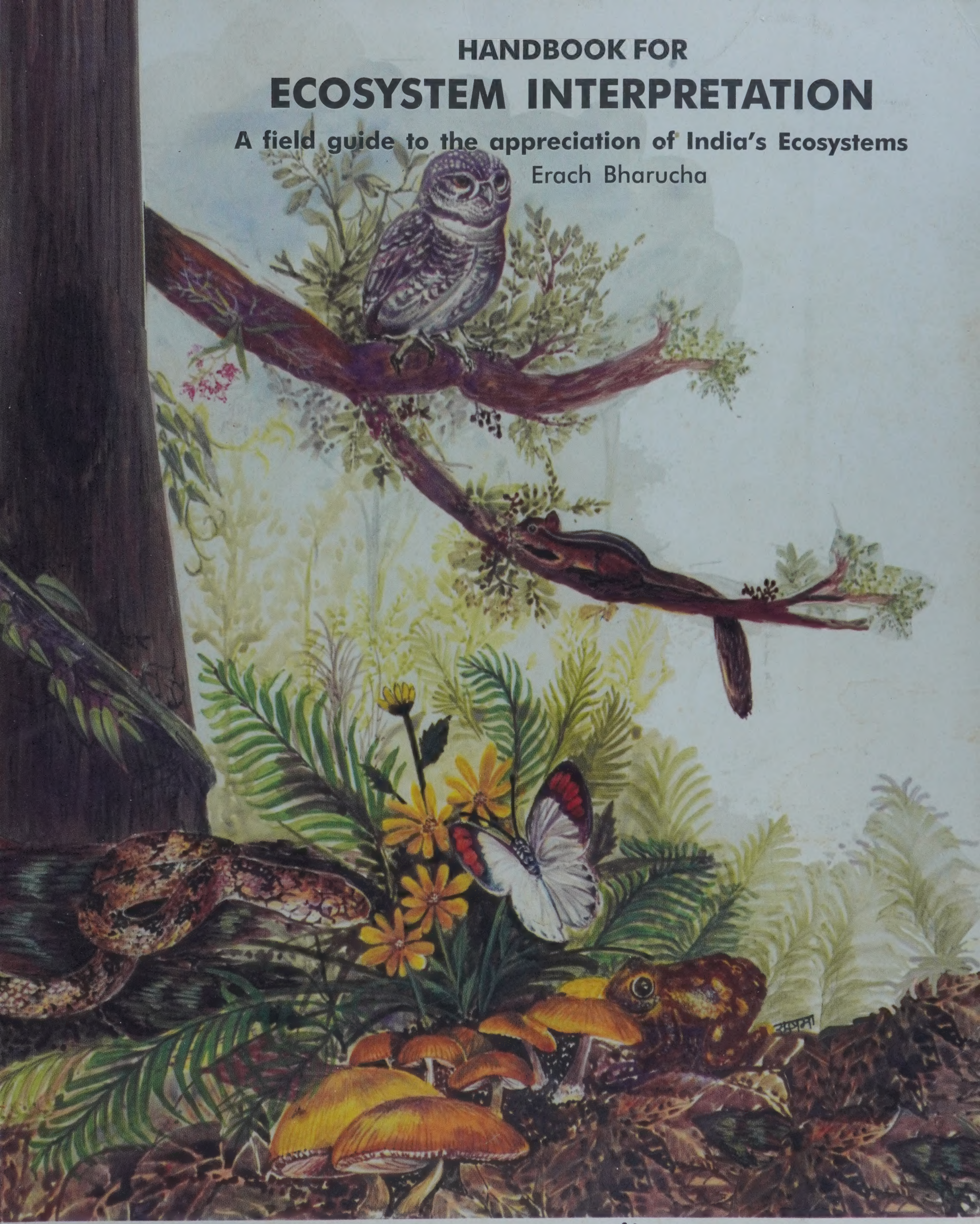
HANDBOOK FOR
ECOSYSTEM INTERPRETATION

A field guide to the appreciation of India's Ecosystems

Erach Bharucha



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HANDBOOK FOR SCHOOL TEACHERS

ECOSYSTEM INTERPRETATION

A field guide to the appreciation of India's Ecosystems

ECOSYSTEMS

THE FORESTS

THE GRASSLANDS

THE DESERT AND SEMI-ARID LANDS

AQUATIC ECOSYSTEMS IN MARINE AND FRESHWATERS

Developed by

Bharati Vidyapeeth
Institute of Environment
Education and Research
Bharati Vidyapeeth
Deemed University, Pune 43

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CONTENTS

INTRODUCTION

How to use the ecosystem handbook and booklets ---- 1

ECOSYSTEMS

Understanding ecosystems ---- 4
The Cycles of nature in Ecosystems ---- 5
The Water Cycle ---- 5
The Carbon Cycle ---- 6
The Oxygen Cycle ---- 7
The Nutrient / Nitrogen Cycle ---- 8
The Energy Cycle ---- 9
Integration of Cycles in Nature ---- 10
Types of ecosystems ---- 11

THE FOREST ECOSYSTEM ---- 13

What is a forest ecosystem? ---- 14
Forest Types in India ---- 15
Forest communities ---- 20
Structure of the Forest ecosystem ---- 21
Ecological cycles in forest ecosystems ---- 23
How are forests used? ---- 25
What are the threats to the forest ecosystem? ---- 27
What if the forests disappear? ---- 28
How can forest ecosystems be conserved? ---- 28
Field Studies in Forest ---- 29

GRASSLAND ECOSYSTEM ---- 34

What is a grassland ecosystem? ---- 35
Grassland types in India ---- 35
Structure of the Grassland Ecosystem ---- 36
The Flora ---- 40
The Fauna ---- 40
How are grasslands used? ---- 43
What are the threats to grassland ecosystems? ---- 43
Why are our grassland species vanishing? ---- 44
What if our grasslands vanish? ---- 44
How can grassland ecosystems be conserved? ---- 44
What should we do? ---- 44

THE DESERT AND SEMIARID ECOSYSTEM

What is a desert or a semi arid ecosystem? ---- 45
Desert and Semiarid land species ---- 46
How are desert and semi arid ecosystems used? ---- 47
What are the threats to desert ecosystems? ---- 47
How can desert ecosystems be conserved? ---- 47

AQUATIC SYSTEMS

What is an aquatic ecosystem? ---- 48
Types of aquatic ecosystems ---- 48
The Pond Ecosystem ---- 49
Lake Ecosystem ---- 51
Streams and River Ecosystems ---- 52
The Marine Ecosystem ---- 53
How aquatic ecosystems are used? ---- 53
What are the threats to aquatic ecosystems? ---- 54
How can aquatic ecosystems be conserved? ---- 54

INTERACTIVE LEARNING FOR STUDENTS FROM NATURE ---- 55

BOX 1.1 Teacher's objectives in the field visit ---- 3
BOX 1.2 Interpreting the Carbon cycle ---- 6
BOX 1.3 Interpreting the Oxygen cycle ---- 7
BOX 1.4 Interpreting the Nitrogen cycle ---- 8
BOX 1.5 Interpreting the energy cycle ---- 10
BOX 1.6 Teacher's objectives in a field visit to an ecosystem ---- 12

BOX 2.1 Field visit to a forest – Depicting nature ---- 14
BOX 2.2 Interpreting the connection between abiotic and biotic aspects of the ecosystem ---- 14
BOX 2.3 Understanding food chains and food pyramids ---- 14
BOX 2.4 Biogeographic Regions of India ---- 19
BOX 2.5 Interpreting the forest type ---- 19
BOX 2.6 Demonstrating the levels in a forest ---- 21
BOX 2.7 The micro habitat for species in different levels of the forest ---- 21
BOX 2.8 Observing food chains and interpreting the food web ---- 23
BOX 2.9 Interpreting the food pyramid and biomass distribution ---- 24
BOX 2.10 Explaining the detritus cycle ---- 24
BOX 2.11 Forest Produce ---- 26
BOX 2.12 Interpreting the temperature and moisture control functions of the forest ---- 26
BOX 2.13 Looking for signs of forest use ---- 27
BOX 2.14 Documenting the cause of forest loss ---- 27
BOX 2.15 Appreciating species diversity ---- 29
BOX 2.16 Appreciating abundance of plant species ---- 30
BOX 2.17 Appreciating abundance of animal species ---- 30
BOX 2.18 The forest as a sponge ---- 30
BOX 2.19 Understanding the detritus cycle ---- 31
BOX 2.20 Understanding prey and predator - food chains ---- 31
BOX 2.21 Searching for examples of food chains, food webs and food pyramids ---- 31
BOX 2.22 Document the linkages between food chains and processes such as pollination of plants in the forest ---- 31
BOX 2.23 Seed dispersal ---- 32
BOX 2.24 Regenaration ---- 32
BOX 2.25 Forest Animal communities and interelationships ---- 32
BOX 2.26 Major prey predator behaviour ---- 32
BOX 2.27 Searching for camouflaged species ---- 33
BOX 2.28 Wildlife signs (Autographs from the wild) ---- 33
BOX 2.29 Feeding patterns of animals ---- 33
BOX 3.1 A field visit to a grassland ---- 35
BOX 3.2 Describe the seasonal changes in the grassland ---- 36
BOX 3.3 Abundance of grassland species ---- 36
BOX 3.4 Uses of grasslands ---- 36
BOX 3.5 Grassland carrying capacity ---- 40
BOX 3.6 Birdwatching in grasslands ---- 42
BOX 3.7 Observing the insect world ---- 42
BOX 3.8 Observe a spider catch its prey ---- 42
BOX 3.9 Documenting animal behaviour ---- 43
BOX 3.10 Understanding grassland food chains ---- 43
BOX 3.11 Mapping landuse in grasslands ---- 43
BOX 3.12 Documenting grassland degradation ---- 43

BOX 4.1 Observing desert and semi arid landscapes ---- 46
BOX 4.2 Observing the fauna of semi arid country ---- 46
BOX 4.3 Mapping land and water resources ---- 47

BOX 5.1 Documenting the nature of aquatic ecosystems ---- 48
BOX 5.2 Studies on the ecology of a pond ---- 49
BOX 5.3 The vegetation zones of a water's edge ---- 49
BOX 5.4 Seasonal field observations of a pond ---- 50
BOX 5.5 Laboratory exploration ---- 51
BOX 5.6 Observations on a lake ecosystem ---- 51
BOX 5.7 Observing what local people use the lake for ---- 51
BOX 5.8 Diversity and abundance of life ---- 52
BOX 5.9 Field observations on a river front ---- 52
BOX 5.10 Resource use ---- 52
BOX 5.11 Water- The greatest of all resources ---- 54
BOX 5.12 What to 'do' in a wetland Sanctuary ---- 54

INTRODUCTION

How to use the Ecosystem Handbook and Booklets

The Handbook links the content of the Textbooks of Science and Geography to field conditions at the local level which can be observed and interpreted for students by the teacher.

For any ecosystem the content of what needs to be known and appreciated, must answer a set of questions.

1. What are the visible and distinguishing features of the ecosystem?
   Observe the structure and functions of the surrounding ecosystems.

2. How is the ecosystem used by people?
   Appreciate the goods and services it provides in ones everyday life.

3. How is it overused or misused?

   Understand how it is degraded due to the unsustainable use of its resources. Identify changes due to degradation of the ecosystem.

4. How can ecosystems be protected?

   The pattern of using resources that are based on Nature's ecosystems can be changed to a sustainable level of utilisation if each and every individual uses resources judiciously.

DISCOVER YOUR WORLD

*Teachers can help students learn about their own environment by observing things around them. Letting students 'discover' nature for themselves is an excellent learning tool. Statements while observing nature can subtly indicate what they should look for. The 'discovered' aspects of Nature can then be discussed and explained. This can be done for each ecosystem and even in school surrounds. What can be observed in each neighbourhood and in each natural ecosystem has been outlined in the '**Discover your world**' section of each ecosystem.*

The handbook for teachers and booklets for students leads to an infusion of environment education into the curricula of Science and Geography. Ecosystems has been identified as a major lacunae that must be understood by school students.

This Environment Education (EE) material enhances knowledge of the environment that can be linked to classroom curriculum of Science and Geography by observing the ecosystem's structure and functions in the field.

Role of the teacher as a Nature interpreter

A. The teacher's role is to generate a high level of awareness of the value of natural ecosystems through field observations activities and audio-visual aids.
   Understanding ecosystem functions through field observations and creating an appreciating of the value of natural resources can be developed by initiating a love for Nature.

B. A conscious effort must be made to create a feeling of concern for natural ecosystems that are being degraded through several human activities in the students' surroundings.
C. A pro-conservation attitude can be developed by stressing on the ways in which these ecosystems can be protected by changing our life styles.

Note:
Environment education has four steps that a teacher must address:

1. Provide ***information*** on the environment, especially related to the students' own surroundings.
2. Create a growing ***awareness*** among students of the value of natural ecosystems and their goods and services.
3. Develop an increasing ***concern*** for the effects of environmental degradation among students.
4. Initiate pro-environment ***action***.

ECOSYSTEMS

1. ECOSYSTEMS

An 'Ecosystem' is a region with a specific landscape form such as a forest, grassland, desert, wetland or coastal area. The nature of the ecosystem is based on its geographical features such as hills, mountains, plains, rivers, lakes, coastal areas or islands. It is also controlled by climatic conditions such as the amount of sunlight, the temperature and the rainfall in the region. The geographical, climatic and soil characteristics form its non-living (abiotic) component. These features create conditions that support a community of plants and animals that evolution has produced to live in these specific conditions. The living part of the ecosystem is referred to as its biotic component.

Ecosystems are divided into terrestrial or land-based ecosystems, or aquatic ecosystems in water. These form the two major habitat conditions for the Earth's living organisms. The number of species known in the world is in the region of 1.8 million. This enormous diversity of life on our earth is essential for mans own survival. Man shares these ecological systems with the rest of the plants and animals on earth. Man is like a single cog in the wheel of nature. If he disturbs nature, the wheel will eventually grind to a halt. Man will not be able to survive on this planet. That is why we refer to our planet as 'mother earth'.

BOX 1.1 Teacher's objectives in the field visit:

*The **major questions** that the teacher must point out during a field visit to any ecosystem such as a forest, grassland, semi-arid, desert, hills, mountain ranges, lake, river or seacoast include:*

- *What is the ecosystem called and its typical features?*
- *How are the ecosystem's goods (products) used? What are its services, (e.g. plants form the oxygen we breathe; we use water for several purposes, and soil forms the basis for agriculture. All these form functioning cycles that support life in the ecosystem. The products an ecosystem produces such as fruit, fish, fuelwood, fiber, fodder for domestic animals and other products can be observed in the field. Who are the people that depend on these products directly? How are all of us indirectly dependent on these products as we buy them for our use? For example we use furnitureand paper made out of wood from a forest. We get fish from the rivers, lakes or the sea. In fact all the things we use indirectly come from the ecological systems.*
- *How are these goods and services of Nature being misused or overused? What are the signs that can be observed of degradation of the environment that have occurred in the area? Deforestation, pollution of a waterbody are signs of degraded ecosystems.*
- *How can this degradation process be prevented by sustainable use of the ecosystem's goods and services by changing the students' own habits, such as by saving water, electricity, paper etc?*
- *How can we all care for our mother earth in a small way? Many small actions together reduce the impact on the ecosystem.*

Understanding Ecosystems

Natural ecosystems include landforms such as the forests, grasslands, deserts, and aquatic ecosystems such as ponds, rivers and lakes, and the sea. Man modified ecosystems include agricultural land and urban or industrial land use patterns.

Each ecosystem has a set of common features that can be observed in the field:

- **'What does the ecosystem look like?'**

  Describe the ecosystem in the student's surroundings by asking them to make observations in the field:

- **What is its structure?**

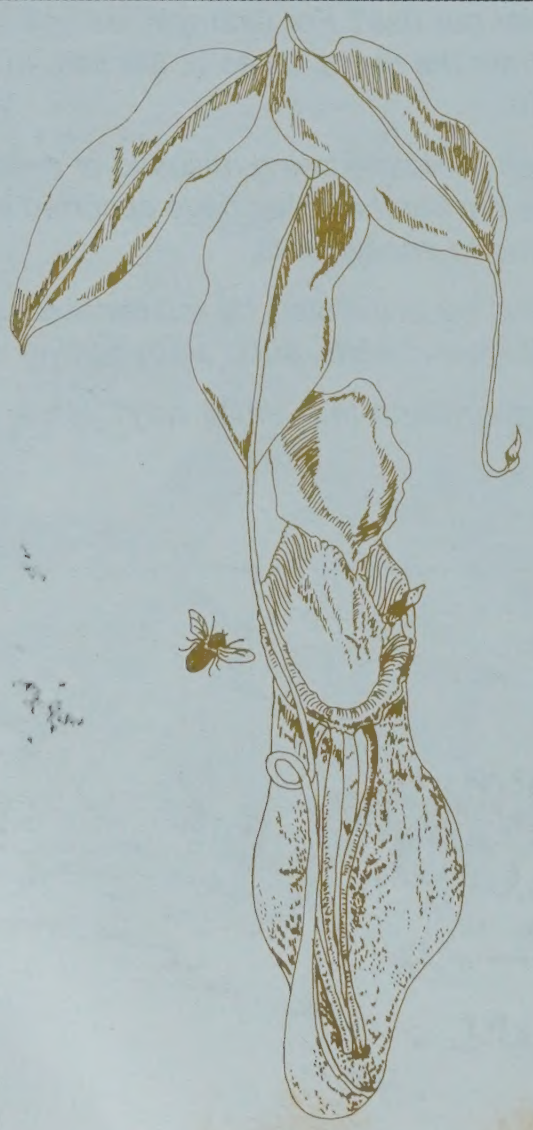
  Is it a forest, a grassland, a water body, an agricultural area, a grazing area, an urban area, an industrial area, etc.?

- **What is the composition of its plant and animal species?**

  List the well-known plants and animals. Document by counting their relative abundance in nature: very common, common, uncommon, rare. Wild mammals may be only a few, cattle would be common. Birds are common – which are most common? Insect life is very common. In fact there are so many that they cannot be easily counted.

- **'How does the ecosystem work'?**

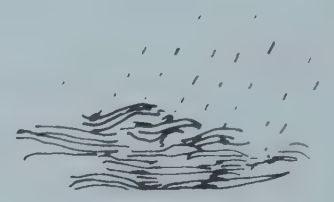
  The ecosystem functions through several cycles and energy transfer mechanisms. Observe and document the components of the ecosystem which consists of its non-living or abiotic features such as air, water, climate and soil. Its biotic components are the various plants and animals. Both these aspects of the ecosystem interact with each other to form Nature's ecosystems. Plants, herbivores and carnivores can be seen to form food chains. All these chains are joined together to form a 'web of life' on which man depends.



The Cycles of nature in Ecosystems

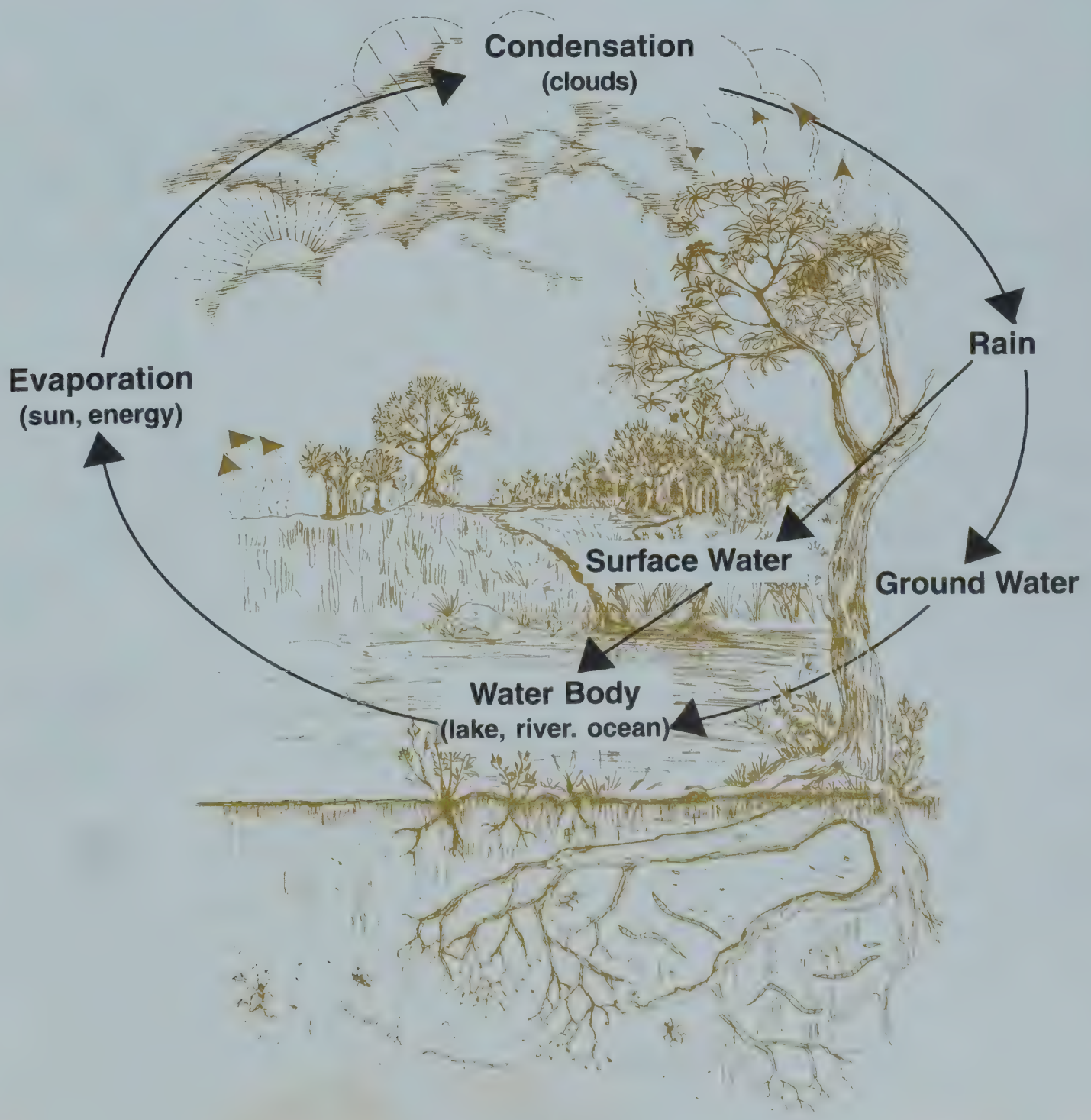
Every ecosystem has several interrelated mechanisms that affect human life. These are the water cycle, the carbon cycle, the oxygen cycle, the nitrogen cycle and the energy cycle. While every ecosystem is controlled by these cycles, in each ecosystem its abiotic and biotic features are distinct from each other.

All the functions of the ecosystem are in some way related to the growth and regeneration of its plant and animal species. These linked processes can be depicted as the various cycles. These processes depend on energy from sunlight, in which carbon dioxide is taken up by plants and oxygen is released. Animals depend on this oxygen for their respiration. The water cycle depends on the rainfall, which is necessary for plants and animals to live. The nutrient cycle recycles nutrients into the soil on which plant life grows.



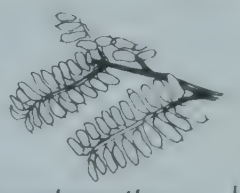
The Water Cycle

When it rains, the water runs along the ground and flows into rivers or falls directly into the sea. A part of the rainwater that falls on land percolates into the ground. This is stored underground throughout the rest of the year. Water is drawn up from the ground by plants along with the nutrients from the soil. The water is transpired from the leaves as water vapour and returned to the atmosphere. As it is lighter than air, water vapour rises and forms clouds. Winds blow the clouds for long distances and when the clouds rise higher, the vapour condenses and changes into droplets, which fall on the land as rain.



The Carbon Cycle

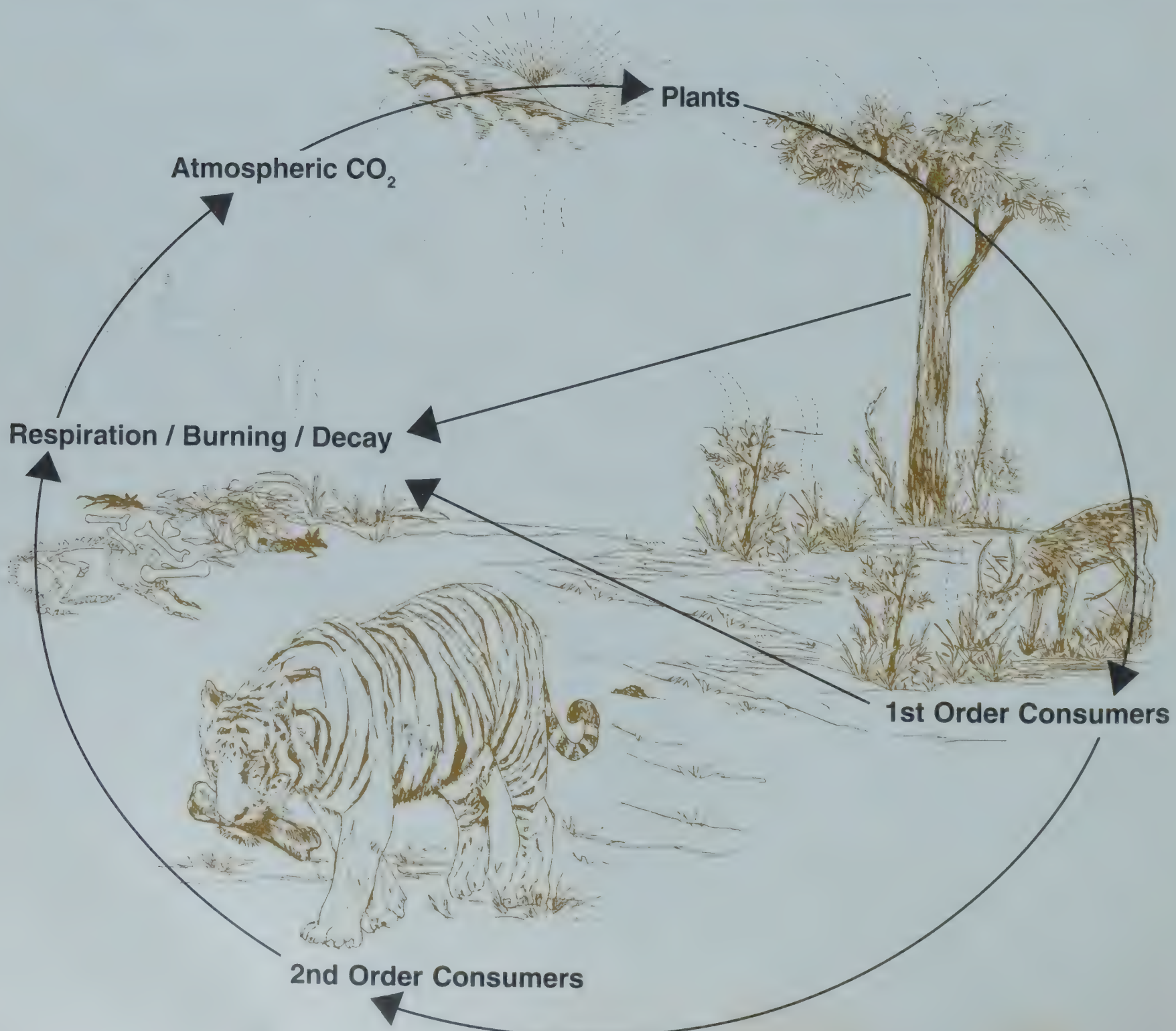
The carbon, which occurs in organic compounds, is found in both the abiotic and biotic parts of the ecosystem. Carbon is a building block of both plant and animal tissues. In the atmosphere, carbon occurs as carbon dioxide, CO_2. In the presence of sunlight, plants take up carbon dioxide from the atmosphere through their leaves. The plants combine carbon dioxide with water, which is absorbed by their roots from the soil. In the presence of sunlight they are able to form carbohydrates that contain carbon. This process is known as photosynthesis. Plants use this complex mechanism for their growth and development. In this process, plants release oxygen into the atmosphere on which animals depend for their respiration. Plants therefore help in regulating and monitoring the percentage of Oxygen and Carbon dioxide in the earth's atmosphere. All of mankind thus depends on the oxygen generated through this cycle.



BOX 1.2 Interpreting the Carbon Cycle:

Explain how plants take up carbon dioxide, which we exhale, and split it to release oxygen which we breathe. Thus we need plants to give us oxygen without which we cannot survive.

Herbivorous animals feed on plant material, which is used by them for energy and for their growth. Both plants and animals release carbon dioxide during respiration. They also return fixed carbon to the soil in the waste they excrete. When plants and animals die they return their carbon to the soil. These processes complete the carbon cycle.

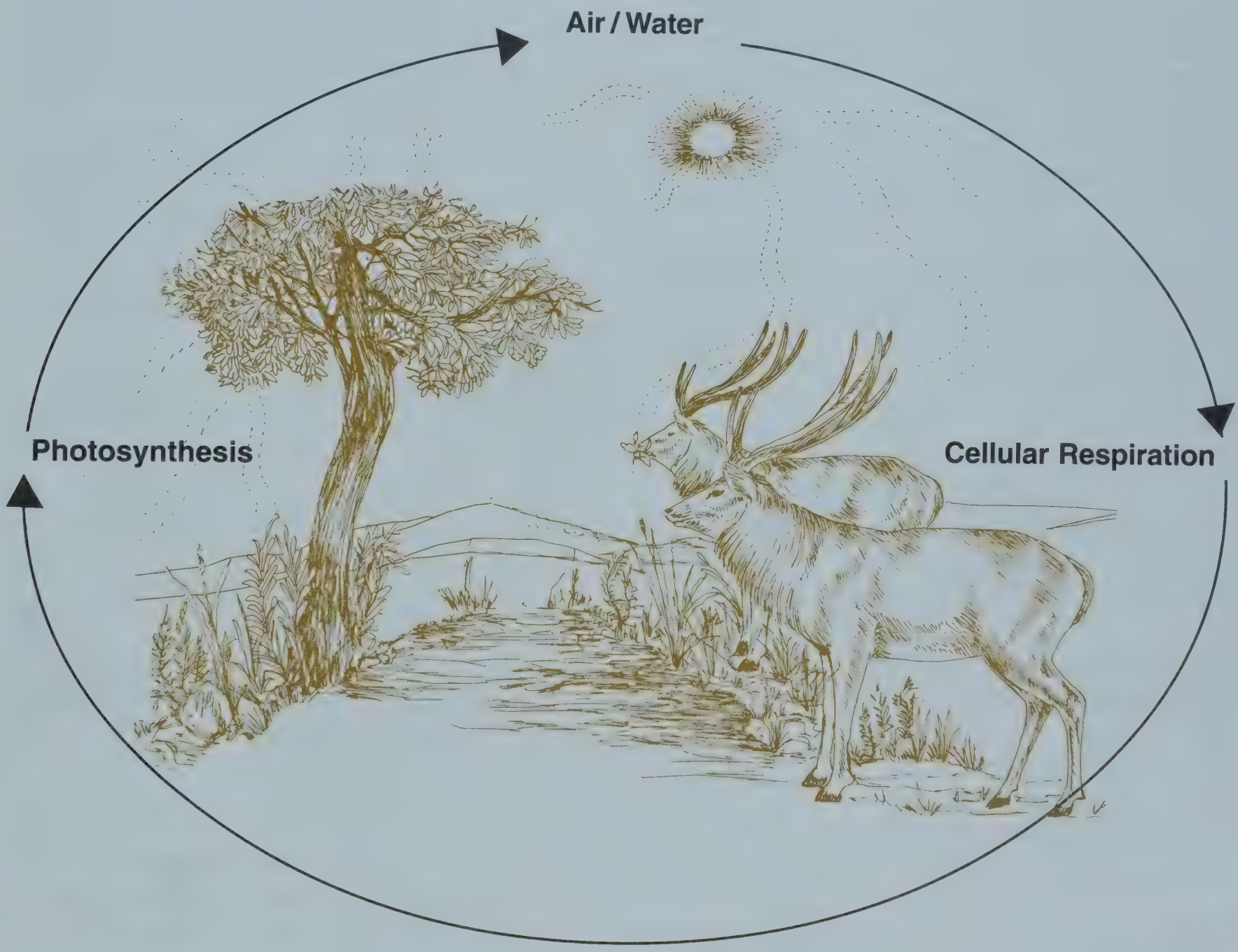


The Oxygen Cycle

Oxygen is taken up by plants and animals from the air during respiration. The plants return oxygen to the atmosphere during photosynthesis. This links the Oxygen Cycle to the Carbon Cycle.

BOX 1.3 Interpreting the Oxygen Cycle:

While on a field trip focus attention on the amount of green material that plants contain. Explain that without this there would not be enough oxygen for animals to breath. Explain that sunlight is essential for photosynthesis, which produces leaves, branches and trunks of trees, the grass that grows every year and even the plants that grow in the water.



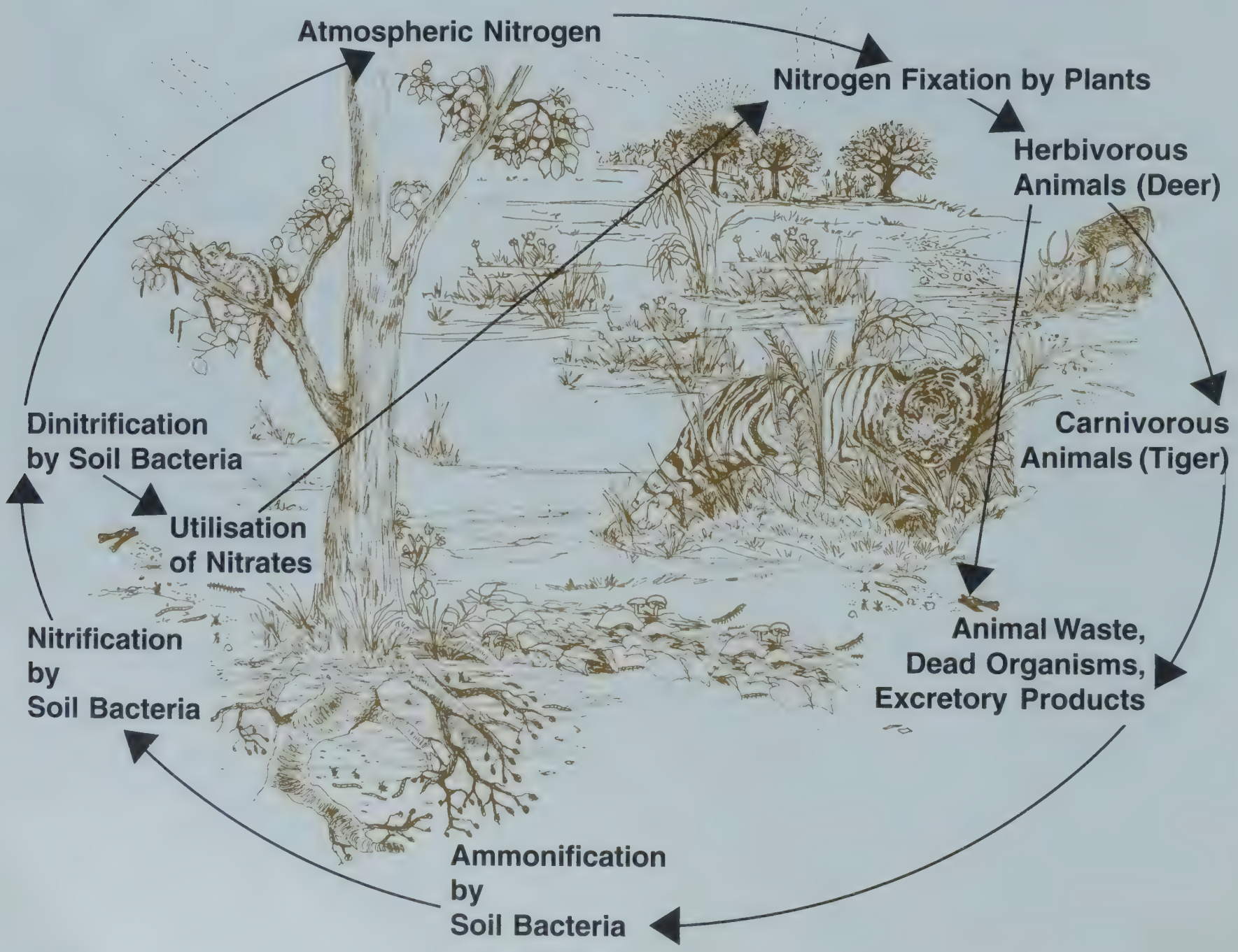
The Nitrogen Cycle

Carnivorous animals feed on herbivorous animals that live on plants. When animals defecate, this waste material is broken down by insects mostly beetles and ants, and other small soil animals into smaller bits on which microscopic bacteria and fungi can act. This material is thus broken down further into nutrients that plants can absorb and use for their growth. Thus nutrients are recycled back from animals to plants. Similarly the bodies of dead animals are also broken down into nutrients that are used by the plants for their growth. Thus the nitrogen cycle on which life is dependant is completed.

The Nitrogen Cycle **: Nitrogen fixing bacteria and fungi in soil gives this important element to plants, which absorb it as nitrates. The nitrates are a part of the plant's metabolism, which help in forming new plant proteins. This is used by animals that feed on the plants. The nitrogen is then transferred to carnivorous animals that feed on the herbivores.**

BOX 1.4 Interpreting the Nitrogen Cycle:

Observe the dried leaves on the ground in a forest, or the dried leaves of plants planted in the area that have collected as detritus. This material can be seen to be decaying. Ants, beetles and worms that feed on this dead material are breaking it up into small fragments. Microscopic bacteria and fungi are acting on this material to convert it into nutrients for plants to grow.

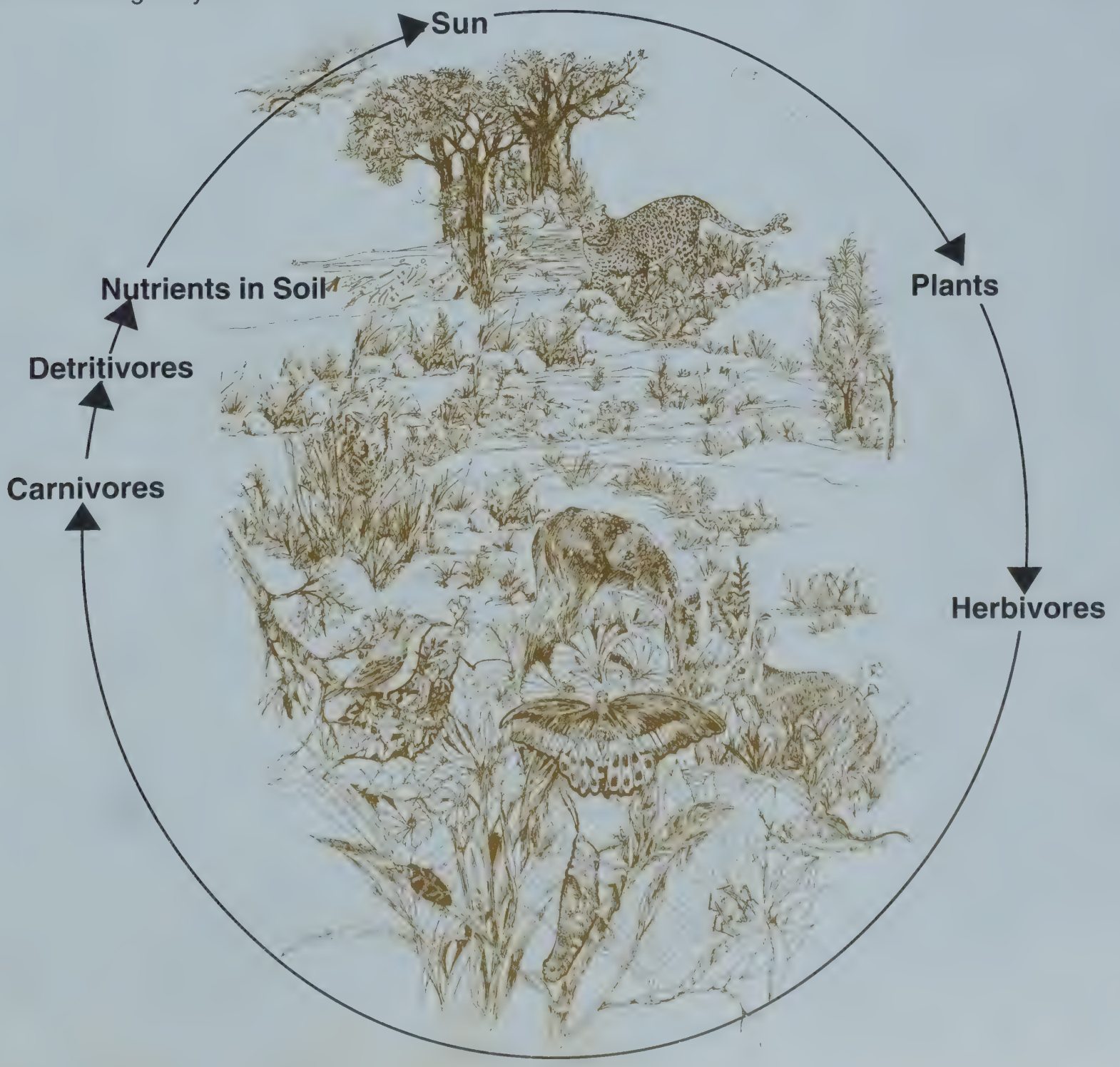


The Energy Cycle

The energy cycle is based on the flow of energy through the ecosystem. Energy from sunlight is converted by plants into plant material which includes leaves, flowers, fruit, branches, trunks and roots of plants. Since plants can grow by converting the sun's energy directly into their tissues, they are known as **producers** in the ecosystem. The plants are used by **herbivorous animals** as food, which gives them energy. A large part of this energy is used up for day to day functions of these animals such as breathing, digesting food, supporting growth of tissues, maintaining blood flow and body temperature. Energy is also used for activities such as looking for food, finding shelter, breeding and bringing up young ones. The **carnivores** in turn depend on herbivorous animals on which they feed. Thus the different plant and animal species are linked to one another through **food chains**. Each food chain has three or four links. However as each plant or animal can be linked to several other plants or animals through many different linkages, these inter-linked chains can be depicted as a complex **food web**. This is thus called the 'web of life' that shows that there are thousands of interrelationships in nature.

The energy in the ecosystem can be depicted in the form of a **food pyramid** or **energy pyramid**. The food pyramid has a large base of plants called '**producers**'. The pyramid has a narrower middle section that depicts the number and biomass of **herbivorous animals**, which are called '**first order consumers**'. The apex depicts the small biomass of **carnivorous animals** called '**second order consumers**'. Man is one of the animals at the apex of the pyramid. Thus to support mankind, there must be a large base of herbivorous animals and an even greater quantity of plant material.

When plants and animals die this material is returned to the soil. This is broken down by insects in the soil. The small bits of plant tissue are further broken down by bacteria and fungi into nutrients that plants absorb through their roots. Animals excrete waste products after digesting food, which goes back to the soil. This links the energy cycle to the Nitrogen cycle.



BOX 1.5 Interpreting the Energy Cycle:

Look for the different types of insects and birds in the trees. Frugivorous birds feed on fruit. Insectivorous birds and spiders feed on insects. These form food chains. There are thousands of such food chains in an ecosystem. These inter-linked chains can be depicted in the form of a 'web of life'. Observe that in our surroundings there is a great amount of plant material. There is much less animal life in which there are a relatively larger number of herbivores than carnivores, which live on herbivorous animals. Make students count and see these differences in number of plants, herbivores and carnivores. This can be drawn as a food pyramid.

Integration of Cycles in Nature:

These cycles are a part of global life processes. These biogeochcemical cycles have specific features in each of the ecosystems. These cycles are however linked to those of adjacent ecosystems. Their characteristics are specific to the plant and animal communities in the region. This is related to the geographical features of the area and the chemical composition of the soil. Together the cycles are responsible for maintaining life on earth. If mankind disturbs these cycles beyond the limits that nature can sustain, they will eventually break down and lead to a degraded earth on which man will not be able to survive.

Types of Ecosystems

Forest Ecosystem

Grassland Ecosystem

Arid and Semi-Arid Ecosystem

Aquatic Ecosystem

BOX 1.6 Teacher's objective in a Field Visit to an Ecosystem:

Observe the local landscape pattern such as forest, grassland, desert, river, hills, etc. and make students identify the type/types of ecosystems they can observe during a field visit. Both the unmodified 'natural' ecosystems and modified ecosystems such as farmland, grazing land, industrial land and urban sectors can be compared and contrasted. Make students document the following:

1. *Common plants they see (trees, shrubs, grasses, etc.).*
2. *Animals observed (mammals, birds, fish, insects, etc.).*

Where possible make students draw a map of the area indicating different ecosystems and land use. It is equally important to express and discuss that the natural landscape is beautiful. That the plants and animals have several exciting features that students can 'discover' for themselves. Their abundance or rarity, their habitat, their behaviour and their links to other species.

2. THE FOREST ECOSYSTEM

Forests are formed by a community of plants which is dominated by trees. Natural vegetation looks vastly different from a group of planted trees, which are in orderly rows. The most 'natural' undisturbed forests are located mainly in our National Parks and Wildlife Sanctuaries. The landscapes that make up various types of forests look very different from each other. Each forest type forms a habitat for a specific community of animals that are adapted to live in it.

Box 2.1 Field Visit To A Forest – Depicting nature:

Identify the nearest or most convenient National Park or Wildlife Sanctuary and organise a field visit to the site. Meet the Forest Official to explain that this is a study tour and not a picnic. Check if there is an Interpretation Centre where there may be local information. Ask for brochures or other material. Officials may agree to address students. Encourage the officials to act as interpreters in the field rather than give a lecture.

Observe the forest type. Students can make notes and drawings from nature.

What is a forest ecosystem?

The forest ecosystem has two parts:

- ***The non-living or abiotic part***: The type of forest depends upon the abiotic conditions in the site. Forests on mountains and hills differ from those in valleys. Vegetation is specific to the amount of rainfall and the local temperature. Forests also vary in their plant communities in response to the type of soil.
- ***The living or the biotic part***: The plants and animals form communities that are specific to each forest type. For instance coniferous trees occur in the Himalayas. Mangrove trees occur in river deltas. Thorn trees grow in arid areas. The snow leopard lives in the Himalayas while the leopard and tiger live in the forests of the rest of India. Wild sheep and goats live high up in the Himalayas. Many of the birds of the Himalayan forests are different from the rest of India. Evergreen forests of the Western Ghats and North East India are most rich in plant and animal species.

BOX 2.2 Interpreting the connection between abiotic and biotic aspects of the ecosystem:

Observe differences in vegetation types during a field trip and relate this to abiotic features such as temperature, rainfall, soil and topographic patterns wherever possible.

The **biotic** component includes both the large (macrophytes) and the microscopic plants and animals.

Plants include the trees, shrubs, climbers, grasses, and herbs in the forest. These include species that flower (angiosperms), and non-flowering species (gymnosperms) such as ferns, bryophytes, fungi and algae.

The **animals** include species of mammals, birds, reptiles, amphibians, fish, insects and microscopic animals.

As the plant and animal species are closely dependent on each other they form different types of forest communities. Man is a part of these forest ecosystems and the local people depend directly on it for a variety of natural resources that act as their life support systems. People who do not live in the forest buy forest products such as wood and paper, which has been extracted from the forest. Thus they use forest produce indirectly from the market.

BOX 2.3 Understanding Food Chains and Food Pyramids:

Appreciating abundance of species in the ecosystem

Observe which plants are found commonly in the forest. Only a few species are very abundant but there are a large number of less common species of trees, shrubs and climbers and small ground plants that add to the diversity of plant life in any forest.

Observe and document the names of animals and classify them as mammals, birds, reptiles, amphibian or insects. Classify these into herbivores and carnivores. If these are counted, the students will appreciate that there is a relatively greater abundance of herbivores than carnivores.

Show students pictures of different types of forests evergreen, deciduous, thorn forests to be able to visualise these differences.

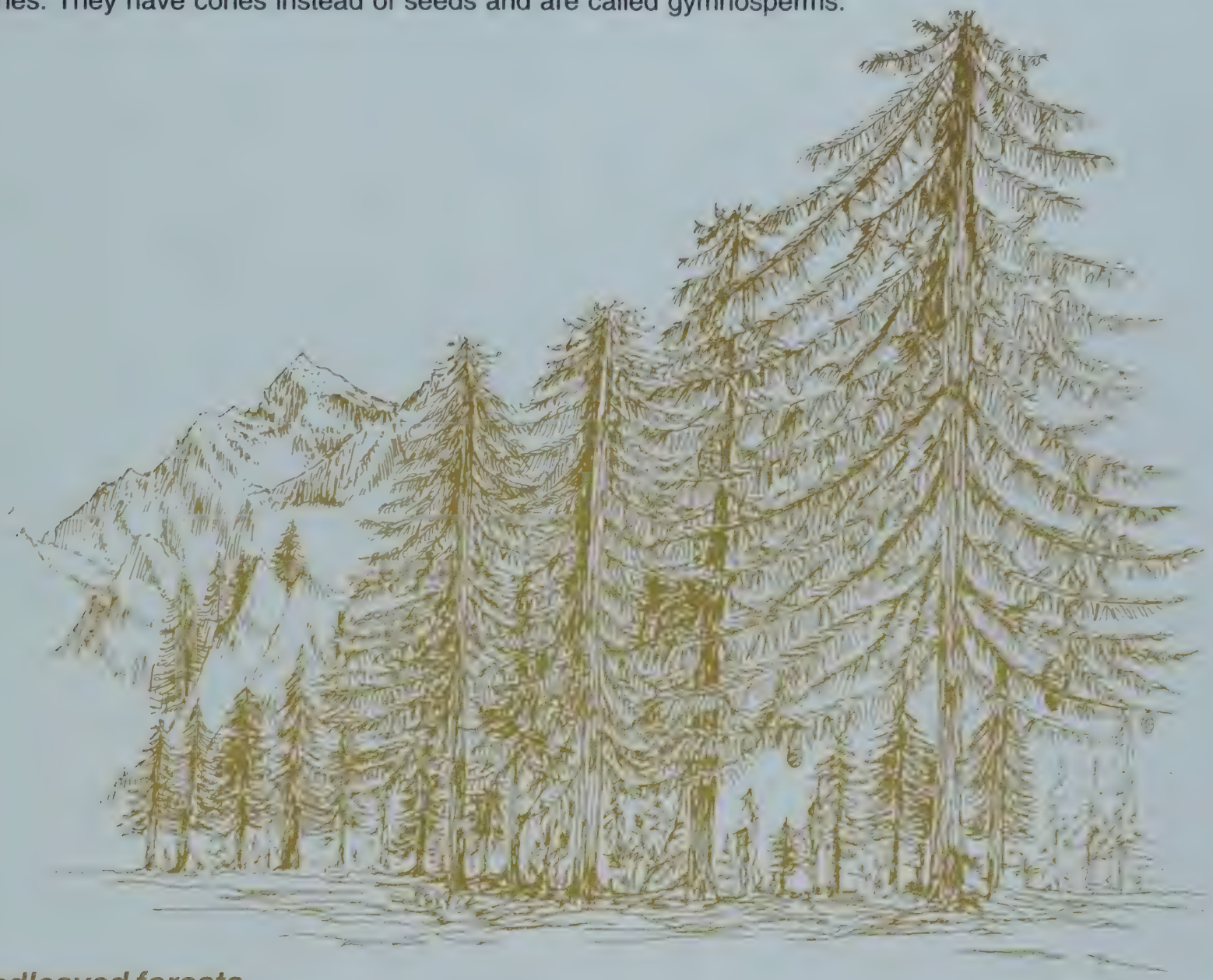
Forest Types in India

Forest types

The forest type depends upon the abiotic factors such as climate and soil characteristics of a region. Forests in India can be divided into Coniferous forests and Broadleaved forests.

Coniferous forests

These forests grow in the Himalayan mountain region, where the temperatures are low. These forests have tall stately trees with needle-like leaves and downward sloping branches so that the snow can slip off the branches. They have cones instead of seeds and are called gymnosperms.



Broadleaved forests

The broadleaved forests have several types. There are Evergreen forests, Deciduous forests, Thorn forests, and Mangrove forests. Broadleaved forests have large leaves of various shapes.

Evergreen forests

They grow in the high rainfall areas of the Western Ghats, North Eastern India and the Andaman and Nicobar islands. The monsoon lasts for several months. Evergreen plants shed a few of their leaves throughout the year. There is no dry leafless phase as in deciduous forests. An evergreen forest remains green throughout the year. The canopy of the trees overlap with each other. Thus very little light penetrates down to the forest floor. Only a few shade loving plants can grow in the ground layer in areas where some light filters down from the closed canopy. The forest is rich in orchids and ferns. The barks of the trees are covered in moss. The forest abounds in animal life and is most rich in insect life.

Deciduous forests

Deciduous forests are found in regions with a moderate amount of seasonal rainfall that lasts for only a few months. Most of the forests in which Teak trees grow are of this type. The *deciduous* trees shed their leaves during the winter and hot summer months. In March or April they regain their fresh leaves just before the monsoon, which grow vigorously during the rains. Thus there are periods of leaf fall and canopy regrowth. The forest frequently has a thick undergrowth as light can penetrate easily onto the forest floor.

Thorn forests

Thorn forests are found in the semi- arid regions of India. The trees, which are sparsely distributed, are surrounded by open grassy areas. Thorny plants are called xerophytic species and are able to conserve water. Some of these trees have small leaves, while other species have thick, waxy leaves. Both these mechanisms prevent loss of water. Thorn forest trees have long or fibrous roots to reach water at great depths. Many of these plants have thorns, which reduce water loss and protect them from herbivores.

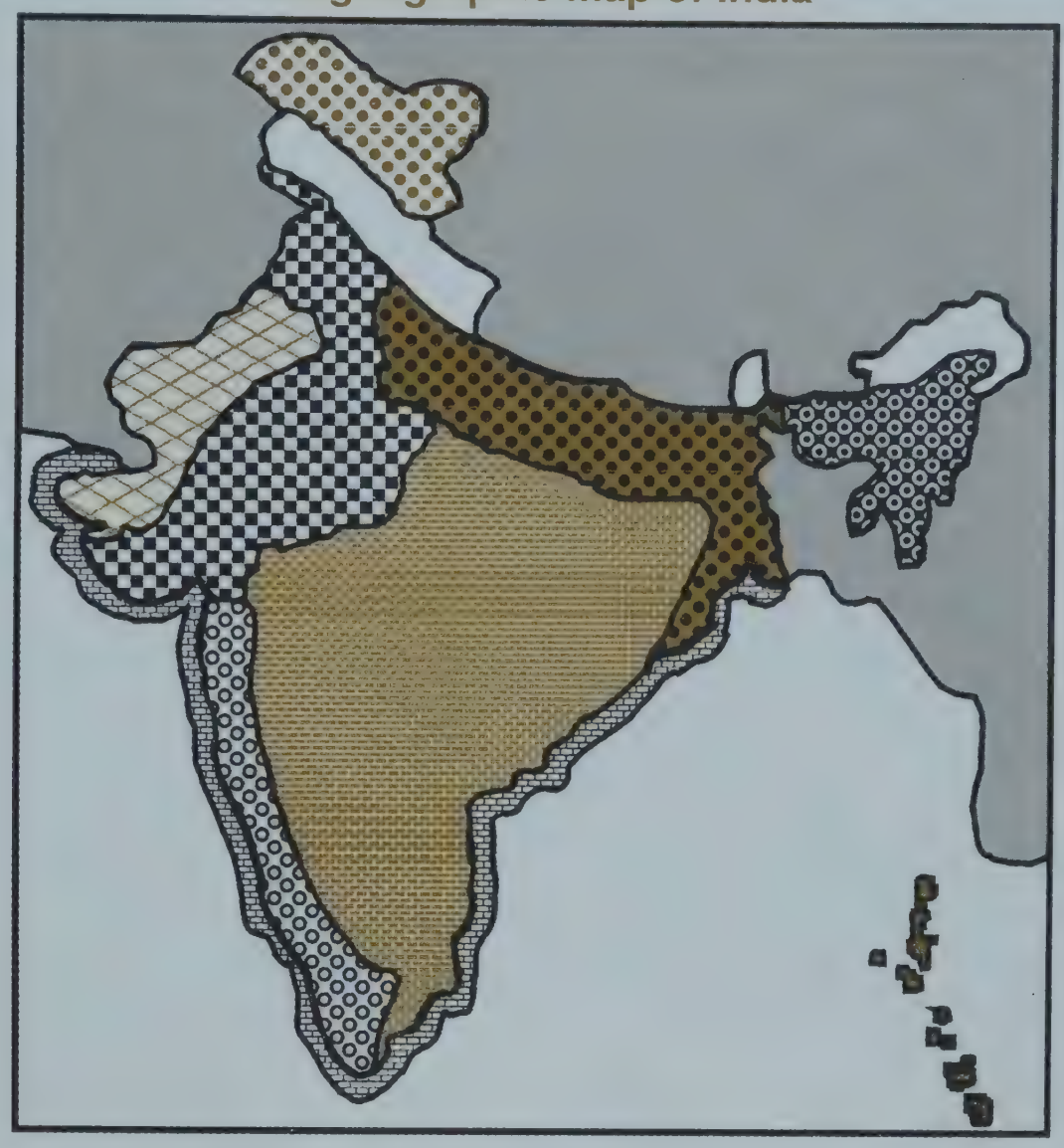
Mangrove forests

Mangrove forests grow along the coast especially in the river deltas. These plants are able to grow in a mix of saline and fresh water, in muddy areas. The mangrove trees have breathing roots that emerge from the mudbanks.

BOX 2.4 Biogeographic regions of India

Identify the type/ types of forests in the region during a field visit and explain its specific features, which fit the type to the name.

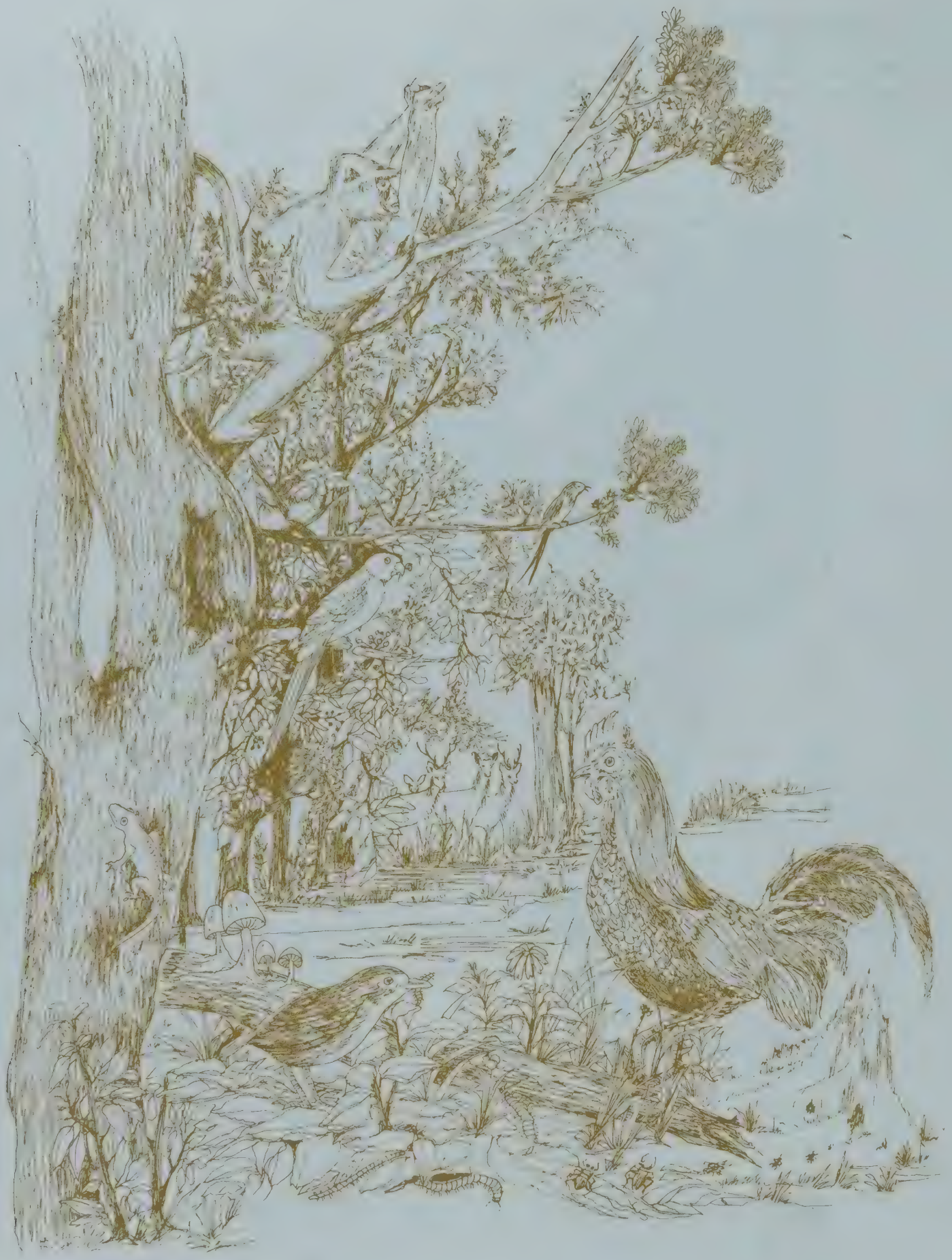
Biogeographic map of India



- Trans Himalayas
- Himalayas
- Gangatic Plain
- North-East India
- Desert
- Semi-Arid Region
- Deccan Plateau
- Western Ghats
- Andaman & Nikobar Islands
- Costal Belt

BOX 2.5 Interpreting the forest type:

During a field trip to a forest identify which type of forest is found in the area. Is there only one type or are there several types? If so why? Pictures that depict the different types form a key to appreciating the different forest types.



Forest Communities:

Forest type	Plants Examples	Animals Examples
Coniferous	Pine, Deodar	Wild Goats and Sheep, Himalayan Black Bear.
Evergreen	Jamun, Ficus	Malabar Whistling Thrush, Tree Frogs.
Deciduous	Teak, Ain	Tiger, Chital, Babblers, Flycatchers.
Thorn	Babul, Ber	Blackbuck, Chinkara, Bustards, Partridge, Monitor lizard.
Mangrove	Avicenia	Water Monitor Lizard, Crocodile.

Structure of the Forest Ecosystem

Each forest type has a distinctive appearance. They form habitats for different communities of plants and animals. Some species occur only in a single forest type and are thus called specialists. Other species are generalists and are found in various forest types.

The structure of a forest can be seen as layers from the ground upwards. The ground layer consists of small plants, grasses, herbs and shrubs that form the undergrowth. The tree trunks form the middle layer, which also has smaller trees and climbers. The upper layer is formed by the crowns of the taller trees, which form the forest canopy.

The forest trees are covered with several types of climbers. Some forest types have large climbers called lianas, which are thick and woody. The trees in high rainfall areas are covered with orchids, ferns, and moss. Along the edges of streams the forest has plants that grow only under very moist conditions.

BOX 2.6 Demonstrating the levels in a forest:

Let the students identify the layers of the forest. Ask them to draw profiles of the structure and label the levels.

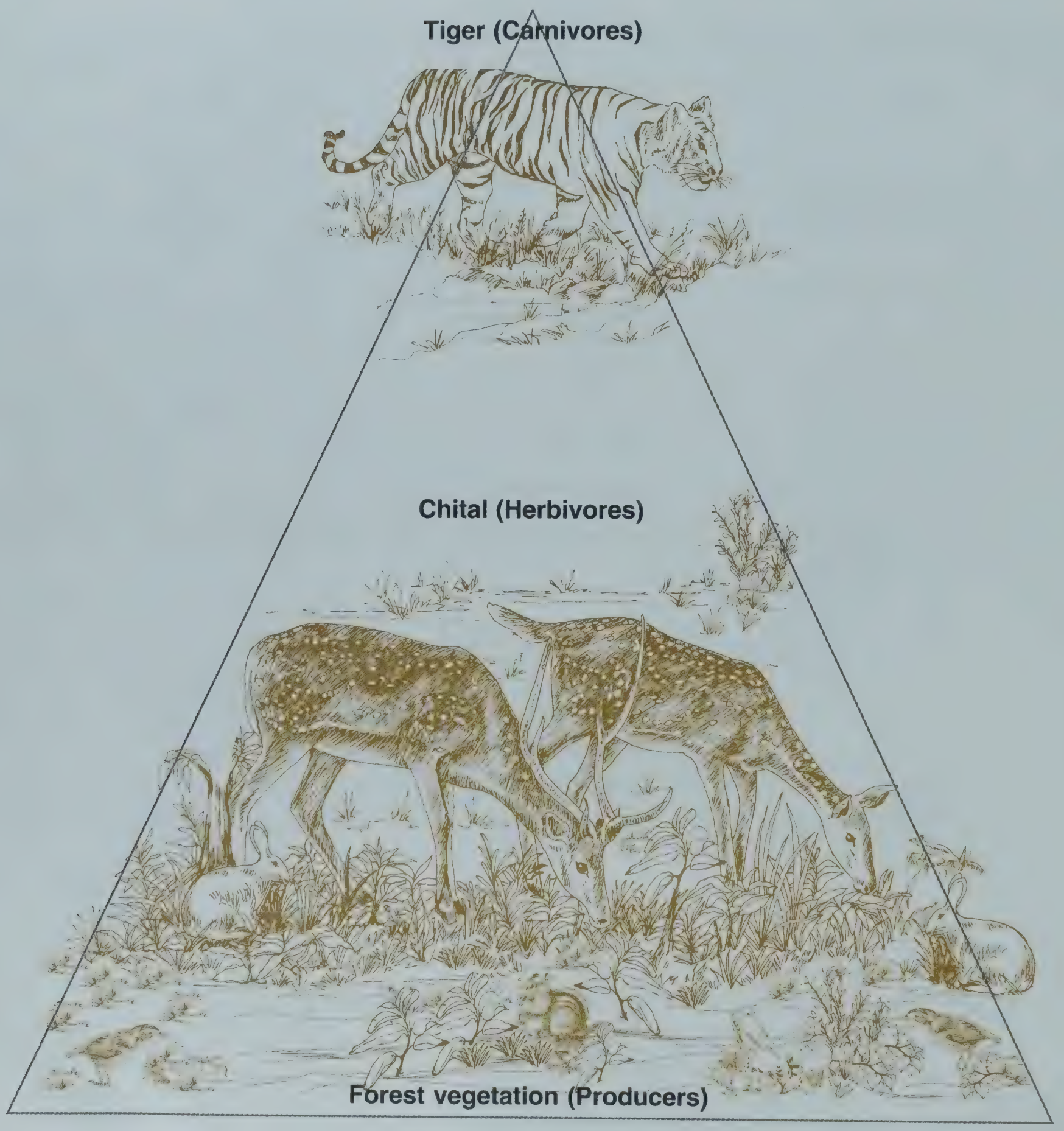
Ground – Trunk – Branches – Canopy.

Most animals live in one or occasionally more than one of the forest's distinctive layers. Monkeys and squirrels live mainly in the canopy. Lizards live on tree trunks. Animals such as leopards and deer live on the forest floor. Some ant species live on the forest floor or under the ground, while others live in the canopy by making a nest with leaves. Birds such as the flycatchers, which feed on insects and bulbuls, parakeets and mynas, which feed on berries and fruit, live in the canopy. Woodpeckers look for insects in the bark of the tree trunks. Other species such as babblers live mostly in the shrub layer. On the ground, there are birds such as partridges, quails and jungle fowl, which feed on worms and seeds. Underground there are burrowing insects and worms, which break down the dead and dying leaf litter into smaller fragments on which bacteria and fungi act to create nutrients which the trees can absorb. Thus each layer in the forest has its own distinctive animals.

BOX 2.7 The micro-habitat for species in different levels of the forest:

Observe which animal uses a different part of a forest habitat. Some live on the ground among the fallen leaves (worms and insects such as ants, termites and beetles), others live in the middle layer on branches and tree trunks (lizards and woodpeckers), many others live in the canopy of the tree tops, (such as fruit and nectar dependant birds such as sunbirds, parakeets and mynas. There are insectivorous birds, (flycatchers, drongos and bee eaters) in the canopy. Several insects live under the ground. If one turns over dead leaves on the forest floor there are a large number of animals (millipedes, ants, beetles etc.)

A FOREST FOOD PYRAMID



BOX 2.8 Observing food chains and interpreting the food web:

Field Observation – examples of food chains that are easily seen

Flower → Butterflies → Spiders
Flowers → Sunbirds → Birds of prey
Fruit → Parakeet → Birds of prey
Seeds → Rodents → Birds of prey
Seeds → Munias → Small carnivorous mammals and birds of prey

Observe what all the animals are feeding on and reconstruct food chains.
Realise that a single species can play a role in several food chains. Thus the chains form a food web.

When it rains, the forest canopy breaks the force of the raindrops so that the soil, which is under the trees, is protected from erosion.

The special features of the Energy Cycle in the forest

The energy cycle of the forest starts with solar energy, which is converted into leaves, branches, flowers and fruit of the trees, shrubs, herbs and grasses of the forest. This is then passed through the various food chains of the forest, to the herbivores and finally the carnivores to reach the apex predators. The forest has complex food chains with herbivores, frugivores, insectivores and carnivores, all linked to several different food chains in the food web. This energy is recycled by the detrivores like insects, fungi and bacteria that break down the dead and decaying plant and animal matter. This provides nutrients in the soil on which plants grow.

Box 2.9 Interpreting the food pyramid and biomass distribution:

Observe that in a forest the number of trees, shrubs and ground cover of plants constitutes an enormous amount of living material (biomass). Compared to this the number and biomass of herbivores is less and the number and biomass of carnivores is the lowest.

Though ants are very small, together the thousands of ants form a large amount of living material. Thus they have a great influence on the ecosystems functions.

The special features of the nutrient/ nitrogen cycle in the forest

The big carnivores such as tigers and leopards feed on large herbivores such as chital and sambar. Small carnivorous such as jungle cats, jackals and foxes feed on rodents such as field mice and hare. The birds of prey such as eagles feed on small prey such as rodents, snakes, frogs and insects. The organic matter from the defecated waste of animals and the dead animals and plants release nutrients back into the soil with the help of detrivores such as insects, fungi and certain bacteria.

Man is closely linked to the forest ecosystem either directly or indirectly for all his day to day needs. Local people collect a variety of forest produce. A large quantity of timber is generated from our forests. All these needs are linked to the nutrient cycle on which plant regrowth depends. If the forest is utilised excessively it cannot regenerate and the forest ecosystem breaks down.

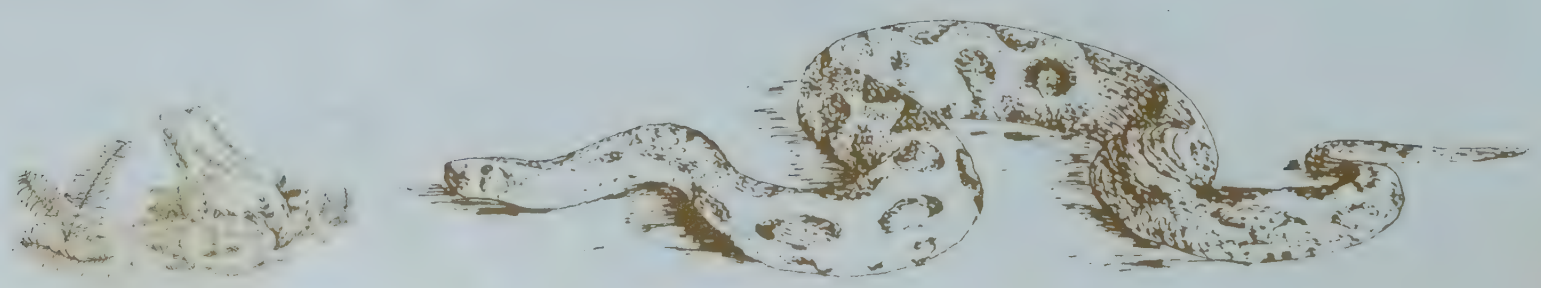
Box 2.10 Explaining the detritus cycle:

Observe the large number of ants and beetles in the dead leaves fallen on the forest floor. Together they constitute a very large mass of living animals. They thus breakdown an enormous amount of dead plant and animal waste material. Without this process the forest ecosystem would loose its integrity.

Ask students to see what ants and beetles do without disturbing them.

The special features of the carbon and oxygen cycle in the forest

A large part of the biomass of a forest is held in the giant tree trunks. This is returned to the soil when the tree dies. The leaves that fall to the ground form the nutrients for fresh plant growth during the year. In an evergreen forest the leaves are gradually shed throughout the year. Thus the detritus is being enriched all through the year. In contrast, in a deciduous forest the leaves are shed all of a sudden increasing the nutrients in the soil during a brief period, which is followed by a growing season when the new leaves and branches of trees are formed. In contrast, in an arid grassland, all the biomass of grass is recycled back into the soil every year.



How are forests used?

Forest products that are collected by people include food such as fruit, roots, herbs and medicinal plants. People depend on fuelwood to cook food, collect fodder for domestic animals, cut building material for housing, collect medicinal plants that have been known for generations for several ailments and use a variety of non timer forest products such as cane to make household articles. Wood from different species of trees have special uses. For instance a soft wood is used for the yok of a bullock cart while a very hard wood is used for its axil. These forest products are of great economic value as they are collected, sold and marketed. Forest dwellers and agricultural people use these goods directly. Other people get them indirectly from the market. Traditional types of agriculture needs forest material such as branches and leaves, which are burnt to form wood ash which acts as a fertiliser for crops such as rice.

Urban people use these forest resources indirectly as all their food and other goods come from agricultural areas that are dependent on the neighbouring forests.

Box 2.11 Forest Produce:

Let students ask local people, especially the women what products they collect from the forest.

Forest services include the control of the flow of water in streams and rivers. Forest cover reduces surface runoff of rainwater and allows ground water to be stored. Forests prevent erosion of soil. Once soil is lost by erosion, it can take thousands of years to reform. Forests regulate local temperature. It is cooler and more moist under the shade of the trees in the forest. Most importantly, forests absorb carbon dioxide and release oxygen that we breathe.

Box 2.12 Interpret the temperature and moisture control functions of the forest:

Observe temperature differences under a closed forest canopy and outside in the open. Feel the moisture in the detritus and superficial layers of soil, which can be compared with the dry soil elsewhere.

The wild relatives of our crop plants and fruit trees have special characteristics in the their genes which are used to develop new crops and newer varieties of fruit. These newer varieties made from wild relatives are resistant to diseases and give greater yields. New industrial products are being constantly produced from the wild plants of the forest. Many of our new medicines come from wild plants.

Direct uses of forest products

Fruits – mango, jamun, awla

Roots – Dioscoria

Medicine – Gloriosa, Foxglove

Fuelwood – many species of trees and shrubs

Small timber for building huts and houses, wood for farm implements

Bamboo and cane for baskets

Grass for grazing and stall feeding livestock

Indirect uses of forest products

Building material for construction and furniture for the urban sector

Medicinal products collected and processed into drugs

Gums and resins processed into a variety of products

Raw material for industrial products and chemicals

Paper from bamboo and softwoods

What are the threats to the Forest Ecosystem?

As forests grow very slowly, we cannot use more resources than they can produce during a growing season. If timber is felled beyond a certain limit the forest cannot regenerate. The gaps in the forest change the habitat quality for its animals. The more sensitive species cannot survive under changed conditions. Overutilizing forest resources is an unsustainable way of misusing our limited forest resources. We are now creating more and more goods that are manufactured from raw material from the forest. This leads to forest degradation and finally changes the ecosystem into wasteland. Wood is illegally extracted from many forests leading to a highly disturbed ecosystem.

Developmental activities such as rapid population growth together with, urbanisation, industrialisation and the increasing use of consumer goods, leads to over utilisation of forest produce. Forests are shrinking as our need for agricultural land increases. It is said that India's forest cover has decreased from about 33% to 11% in the last century. The increasing use of wood for timber, wood pulp for paper and the extensive use of fuelwood results in continual forest loss. Forests are also lost by mining and building dams. As the forest resources are exploited beyond what they can produce the forest canopy is opened up, the ecosystem is degraded, and its wildlife is seriously threatened. As the forest is fragmented into small patches its wild plant and animal species become extinct. These can never be brought back. Extinction is forever.

Box 2.13 Looking for signs of forest use:

Several signs tell us how the forest is used by people.

Look for human footprints and hoof marks of domestic animals, which demonstrates the dependence of man and his animals on forest vegetation. People cut the branches of the trees for fuel wood. The cut stumps of branches can be seen all around in a heavily lopped forest. These are the signs of lopping of branches used for fuelwood by local people. All the energy required to cook meals and heat their homes in winter is thus forest dependent.

Stumps of trees show the number of poles used for building houses, or that have been felled and sold.

Observe the number of cattle tracks and cow dung piles, which tell where the local people graze their domestic animals. Specially look for cattle tracks near watering places.

Ask local people what they collect from the forest. Fruits, leaves, roots, nuts, fuelwood, timber, honey, fibre, cane, gum, resins, are all forest products of great value.

Observe the environment in a neighbourhood village. See the various products used by the people, or marketed by them, which they get from the forest.

Where do they get their water? The presence of water in the streams is related to the existence of the forest.

Box 2.14 Documenting the cause of forest loss:

Observe areas around villages where forest is overused and contrast this to the intact vegetation of Sanctuaries and National Parks.

What if the forests disappear?

When forests are cut down tribal people who depend directly on them for food and fuelwood find it very difficult to survive. Agricultural people do not get enough fuelwood, small timber, etc. for making houses and farm implements. Urban people who depend on food from agricultural areas, which in turn depend on neighbouring forest ecosystems have to pay a higher price for food as human population grows.

Insects that live and breed in the forest such as bees, butterflies and moths decrease in abundance once forests are degraded. As their numbers decrease they are unable to effectively pollinate agricultural crops and fruit trees. This leads to a decrease in agricultural yields.

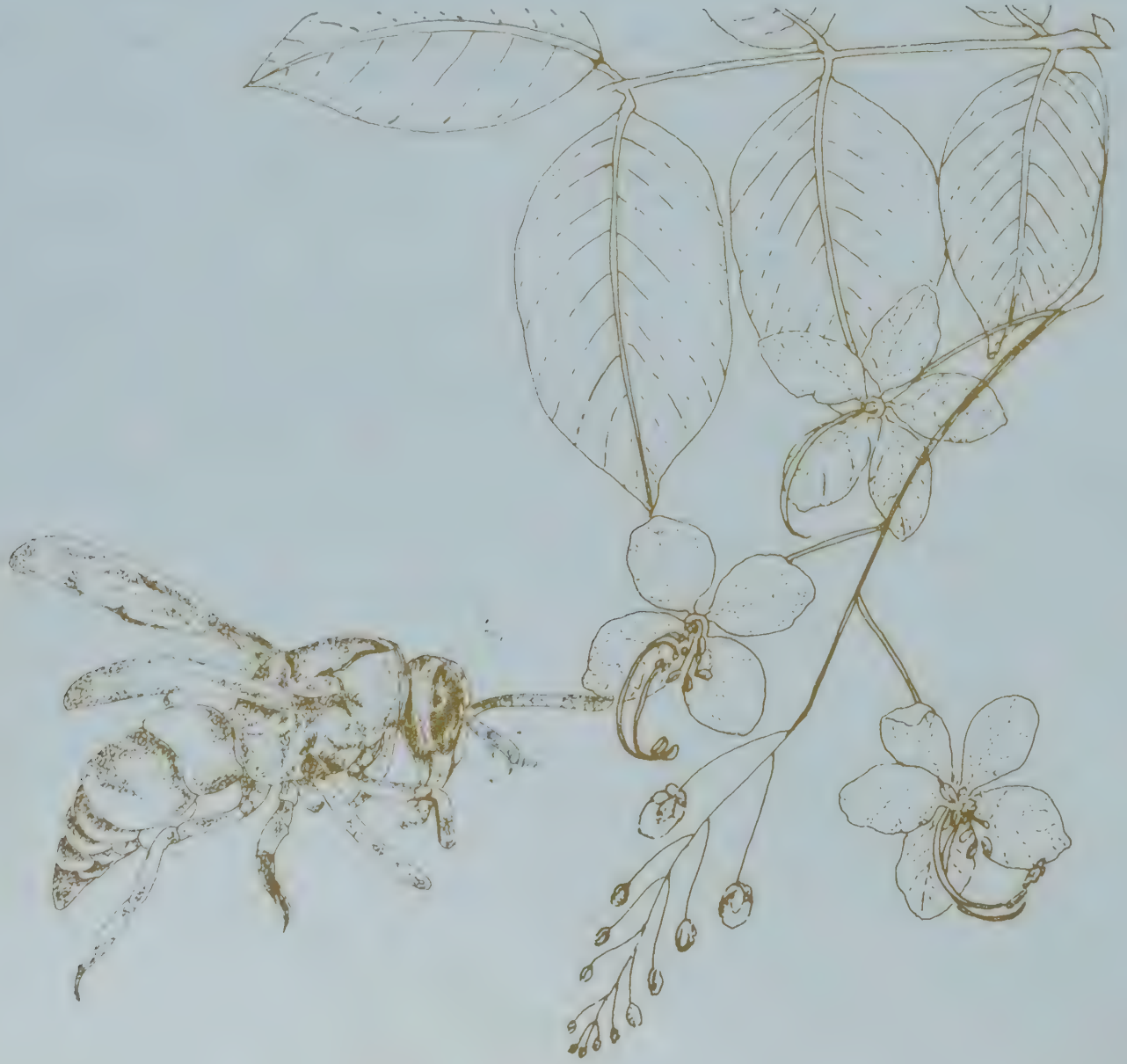
The rain that falls on deforested land flows directly into nearby rivers. Thus water is not retained under the ground. People thus do not get a sufficient quantity of water throughout the year. The exposed soil is rapidly washed away during the rains once the protective forest cover is removed. Thus agriculture is seriously affected in such areas. In deforested areas, the water in streams is brown in colour as soil is washed away while water in forested streams is crystal clear.

Wild animals lose their habitat. This leads to extinction of our precious species. Residual forests must be protected from being destroyed any further if all the diverse species of plants and animals are to be kept for future generations.

How can Forest Ecosystems be conserved?

We can conserve forests only if we use its resources carefully. This can be done by using alternate sources of energy instead of fuelwood. There is a need to grow more trees than are cut down from forests every year for timber. Afforestation needs to be done continuously from which fuelwood and timber can be judiciously used.

The natural forests with all their diverse species must be protected as National Parks and Wildlife Sanctuaries where all the plants and animals can be preserved.



Field Studies in Forests

Plant Diversity

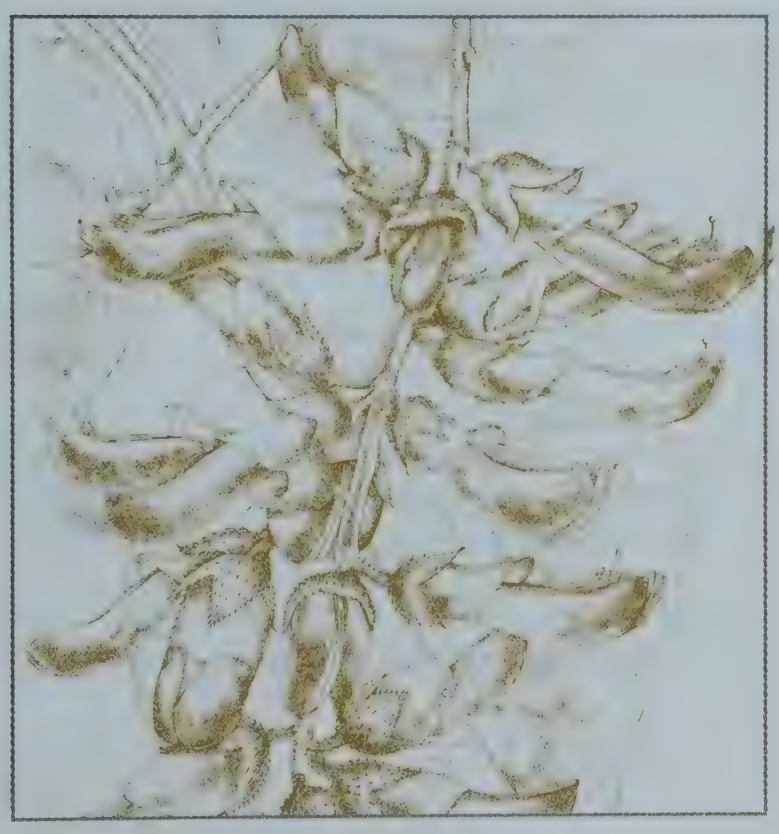
There are a large variety of plant species in any environment. A great diversity of plants are found in the natural vegetation of undisturbed natural forests. There is also plant diversity in the variety of crops that are grown in traditional agricultural areas. In rural areas trees are planted for fruit, fuelwood and timber. In urban areas tree planting is done for shade along roadsides and to green the landscape. Loss of tree cover creates serious problems for us all in every ecosystem.

In an evergreen forest there could be as many as a hundred tree species and as many species of shrubs. The ground flora includes many more species of grasses and herbs. A special feature is its large variety of orchids and ferns. Deciduous forests have a somewhat lower diversity of tree species.

Look around and see how many different types of plants there are in any area. There are many more species in forests than in plantations or agricultural areas.

Box 2.15 Appreciating species diversity:

Make a rough estimate of the number of species of the trees, shrubs and the different plants that form the ground cover. One need not name them all. Appreciating the wide variety of plants is as important as learning their names.



Box 2.16 Appreciating abundance of plant species:

Look around at the trees in the forest. Only a few are very abundant, while a much larger number of species are uncommon. Encourage students to identify the most commonly observed trees.

Appreciate that there are many rare species of plants. These can become extinct if the forest is cut down.

Box 2.17 Appreciating abundance of animal species:

On the forest floor the most commonly observed animals are ants. There are more ants than any other animal species on earth. Look for beetles. There are more species of beetles in the world than any other group of species. Observe how many different types of beetles there are.

The integrity of the ecosystem is based on these small but very important species that are a major part of the web of life of the forest. Explain that they are the prey of insectivorous birds, amphibians and rodents.

Insects break down the detritus of the forest, which is the nutrient material on which the forest plants grow.

Mankind thus cannot survive without these ants as they produce the nutrient material on which plants depend. Man is dependent on plant life, and is thus indirectly dependent on the insects in the forest detritus.

Box 2.18 The forest as a sponge:

How do forests influence the water cycle?

Feel the coolness of the forest air and compare this with the warmer temperature outside the forest cover. The difference is obvious as shade of the trees reduces the local temperature. Feel the level of moisture on the forest floor and compare this to the dryness of the ground outside the forest. A considerable amount of moisture is retained in the dead leaves (humus) of the forest floor. Dig a small hole in the ground. It is moist and cool under the forest floor. This demonstrates how the forest acts as a sponge and releases water gradually into streams after the monsoon is over. This can continue for the rest of the year and provide water for people outside the forest.

Box 2.19 Understanding the detritus cycle:

Observe the insects and earthworms moving on the forest floor. They are breaking down the detritus so that microscopic fungi and bacteria can recycle this material into nutrients for the forest plants to grow. Look for the larger fungi such as mushrooms and bracket fungi that also do this work. This shows how the nutrient cycle works.

Box 2.20 Understanding Prey and Predator – Food chains:

There are spiders on the ground, which form tunnel webs to catch the crawling insects. In the trees wood spiders make giant webs three feet in diameter to catch flying insects. Look for the insect life in the canopy of the trees, on trunks, on the ground and especially under dead fallen leaves.

Box 2.21 Searching for examples of food chains, food webs and food pyramids:

Different species of lizards are found on the tree trunks and on the forest floor. There are chameleons in the trees and skinks on the ground. They are feeding on insect life, which in turn feed on the plants. This is a simple food chain that can be easily observed.

A spider catching an insect in its web is another demonstration of a simple food chain. The same insects are used by spiders and lizards as prey. Thus multiple food chains are linked to each other. This forms the food web of the forest.

There has to be a very large amount of plant life to provide enough food for the herbivores, which are prey species for the very few carnivores in the forest. This demonstrates how a food pyramid works and how energy moves from one level to the other. The energy is used for day to day functions of animals such as hunting for food, respiration, metabolising food and breeding. Observe that there is a very large amount of plant life, a smaller number of herbivores and very few carnivores. This observation explains the concept of the food pyramid.

Box 2.22 Document the linkages between food chains and processes such as pollination of plants in the forest:

Animals such as monkeys, squirrels and birds feed on leaves, fruits and seeds. Insects such as butterflies and moths and birds such as sunbirds and mynas use flower nectar for food. These flowers have bright colours to attract them. During this process the insects and birds pollinate the plants.

At night when most animals sleep, the bats and moths pollinate flowers. These flowers are usually white in colour so that they can be seen at night.

Thus many plants depend on animals to pollinate them so that seeds can develop. The regeneration of forests thus depends on these animals. These linkages are important aspects that maintain the forest's web of life.

Look for the pollinators – butterflies, moths, beetles, ants and nectar feeding birds are easy to observe.

Look for birds that eat berries and fruit and disperse seeds.

Box 2.23 Seed Dispersal:

Observe that monkeys, squirrels and birds such as parakeets, mynas and hornbills are agents of seed dispersal as they feed on fruit and spread the seeds far and wide. Birds such as bulbuls eat small berries along with their seeds. After passing through the birds' intestines they are defecated. They easily germinate as their covering is removed in this process. The birds thus help in the dispersal and regeneration of plants. Though a plant is rooted to the same spot, evolution has linked plants with animals that help the plant species to spread by spreading their seeds.

Other seeds are light and have wings or hair which are dispersed by the wind. Observe how these float thought the air for long distances.

Box 2.24 Regeneration:

Observe how the different birds feed on plant material. Look for seeds and seedlings growing on the forest floor. Observe that while there are plenty of small seedlings there are fewer saplings as a majority of seedlings die. Only a few of the surviving young saplings will finally grow into large trees. Plants thus need to generate a very large number of seeds. Only those seeds that find a spot that has all the conditions needed for their germination and growth can end up as large trees. Many seedlings die due to forest fires, grazing or trampling by domestic animals.

2.25 Forest Animal Communities and interrelationships:

Forest birds form feeding parties of many different species. Together they feed on different things such as flower nectar, fruit, or insects. Observe that when fruit eating birds search for their food in the foliage they disturb the hiding insects which are thus caught by the insect dependent birds. Others while looking for berries in the bush layer disturb insects that are caught by other insectivorous birds. Thus birds of different species help each other in finding their food and stay together in large mixed feeding parties that move from one tree to another. Identify what each bird species feeds on.

When the langurs feed on fruit, a part of the fruit is dropped uneaten on the forest floor. Chital and sambar deer following the langurs are able to eat this fallen fruit. From the top of the tree the monkeys can easily spot an approaching tiger or leopard more easily than the deer. The monkey gives an alarm call at the approach of a predator alerting the deer to its approach.

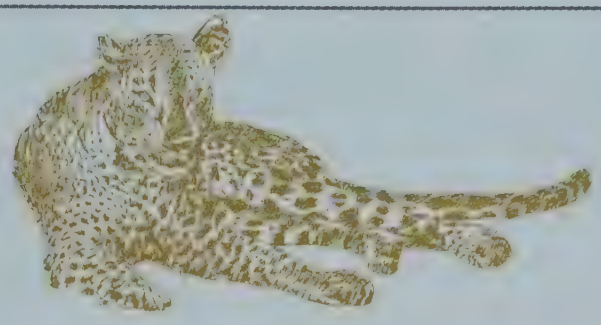
Box 2.26 Major prey- predator behaviour:

Carnivorous animals are very shy of human beings as man has killed them for thousands of years. These animals have learned to be very stealthy so that they can catch their wary prey. The predators have to make several unsuccessful attempts before they catch their prey. For these unsuccessful attempts they have to spend a large amount of energy to catch the watchful deer. The deer have sharp eyesight and a good sense of smell to help avoid being caught. Predators counter this by moving very cautiously in the forest.

Box 2.27 Searching for camouflaged species:

The beautiful stripes of the tiger and the rings of the leopard match the light and shade in the forest and thus camouflage these animals so that they cannot be easily seen. They can sometimes be only a few paces away in the undergrowth and yet remain completely invisible. Predators such as tigers and leopards frequently see us before we see them and disappear stealthily into the deeper forest. However we can observe their pug marks on the forest floor. It is exciting to see a fresh pugmark in the forest. It tells a tale. The track if fresh can end up at a sleeping tiger or a leopard!

The colour of moths is similar to that of the brown tree bark on which they rest during the day. Chameleons change their colour to suit their surroundings. The green colour of grasshoppers matches the foliage they live in. stick insects look like twigs.



Box 2.28 Wildlife signs (Autographs from the wild):

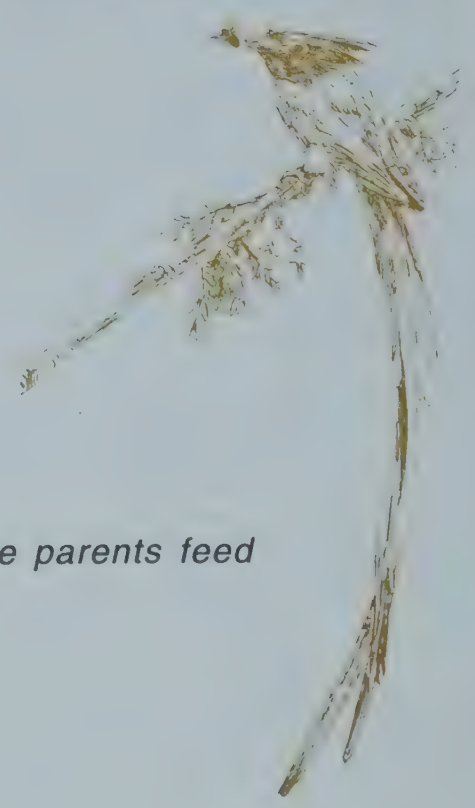
The wildlife of the forest leaves behind several signs even if we cannot see the animals themselves. Each animal has its own footprint, which can be identified. Animals also leave their characteristic droppings that can be easily identified. Thus these signs in the forest can tell us which species live there and indicate their day to day activities.

Listen to the bird calls. There are many different kinds of beautiful calls. This indicates that there are many more birds than we can see in the forest.

Box 2.29 Feeding patterns of animals:

Observe the feeding patterns of forest animals. Learn about those that we cannot observe easily. Some of these are given below:

- *Tigers feed on sambhar, chital deer and monkeys.*
- *Leopards feed on barking deer, hare, and occasionally village cattle*
- *Jackals feed on hare, mice, and birds.*
- *The Jungle cat feeds on hare and mice.*
- *Pangolins feed on ants.*
- *Mongoose feeds on snakes and mice.*
- *Cheetal feed on grass.*
- *Barking deer feed on fruit and leaf buds.*
- *Squirrels feed on nuts and fruit.*
- *Porcupines feed on fleshy roots of plants and bark of trees.*
- *Birds of prey feed on rodents, reptiles, frogs and small birds.*
- *Birds like flycatchers feed on insects and worms.*
- *Bulbuls feed on fruit. When they have young one's in the nest the parents feed the chicks with worms and caterpillars.*
- *Sunbirds feed on flower nectar.*
- *Spiders catch insects.*
- *Insects like beetles and bugs feed on plant material.*
- *Insects like the praying mantis feed on other smaller insects.*
- *Ants and termites feed on plant material that is dead.*
- *Beetles feed on leaves and sap of plants.*
- *Butterflies feed on flower nectar in the day.*
- *Moths feed on flower nectar at night.*
- *Worms feed on forest detritus.*



GRASSLAND ECOSYSTEMS

Semi-Arid Grassland

Shola Grassland

Terai Grassland

3. GRASSLAND ECOSYSTEMS

A wide range of landscapes in which the vegetation is mainly formed by grasses and small annual plants are adapted to India's various climatic conditions. These form a variety of grassland ecosystems with their specific plants and animals.

What is a grassland ecosystem?

Grasslands cover areas where rainfall is usually low and the soil depth and quality is poor. The low rainfall prevents the growth of a large number of trees and shrubs, but is sufficient to support the growth of grass cover during the monsoon. Many of the grasses and other small herbs become dry and the part above the ground dies during the summer months. In the next monsoon the grass cover grows back from the root stack and the seeds of the previous year. This change gives grasslands a highly seasonal apperance with periods of increased growth followed by a dormant phase.

A variety of grasses, herbs, and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grass covered areas. These animals are able to live in conditions where food is plentiful after the rains, so that they can store this as fat that they use during the dry period when there is very little to eat. Man began to use these grasslands as pastures to feed his livestock when he began to domesticate animals and became a pastoralist in ancient times.

Grassland Types in India:

Grasslands form a variety of ecosystems that are located in different climatic conditions ranging from near desert conditions, to patches of grasslands that occur on hillslopes alongside the extremely moist evergreen forests in South India. In the Himalayan mountains there are the high cold Himalayan pastures. There are tracts of tall elephant grass in the low-lying Terai belt south of the Himalayan foothills. There are semi-arid grasslands in Western India. Central India, on the Deccan Plateau.

The ***Himalayan pasture belt*** extends upto the snowline. The grasslands at a lower level form patches along with coniferous or broadleaved forests. Himalayan wildlife require both the forest and the grassland ecosystem as important parts of their habitat. The animals migrate up into the high altitude grasslands in summer and move down into the forest in winter when the snow covers the grassland. These Himalayan pastures have a large variety of grasses and herbs. Himalayan hill slopes are covered with thousands of colourful flowering plants. There are also a large number of medicinal plants.

The ***Terai*** consists of patches of tall grasslands interspersed with a Sal forest ecosystem. The patches of tall elephant grass, which grows to a height of about five meters, are located in the low-lying waterlogged areas. The Sal forest patches cover the elevated regions and the Himalayan foothills. The Terai also includes marshes in low-lying depressions. This ecosystem extends as a belt south of the Himalayan foothills.

The ***Semi-arid plains of Western India, Central India and the Deccan*** are covered by grassland tracts with patches of thorn forest. Several mammals such as the wolf, the blackbuck, the chinkara, and birds such as the bustards and floricans are adapted to these arid conditions. The Scrublands of the Deccan Plateau are covered with seasonal grasses and herbs on which its fauna is dependent. It is teaming with insect life on which the insectivorous birds feed.

The ***Shola grasslands*** of the Shola forests of the Western Ghats, Nilgiri and Annamalai ranges are formed by a patchwork of grassland and forest habitats on the slopes of these hills. The forests occur in depression and along nala courses.

Grasslands are not restricted only to low rainfall areas. Certain grassland types form either clearings in different forest types, or are located on the higher steep hill slopes with patches of forest that occur along the streams and in depressions.

The grasses are the major producers of biomass in these regions. Each grassland system has a wide variety of species of grasses and herbs. Some are more sensitive to excessive grazing and are suppressed if the area is over grazed. Others are destroyed by repeated fires and cannot regenerate. Thus over-used or frequently burnt grasslands are degraded and are poor in plant species diversity.

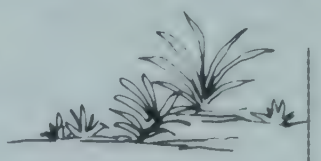
Box 3.1 A Field Visit To A Grassland:

Arrange a field visit to a Grassland.

Observe the variety of plant and animal life in a grassland. Document the food used by each animal that is identified.

Structure of the Grassland Ecosystem

A grassland ecosystem has a typical set of non-living features due to the dry climatic conditions and poor soil. Evolution has adapted its special plants and animals to survive in these harsh and seasonally changeable conditions over millions of years.



Box 3.2 Describe the seasonal changes in the grassland:

Ask students to describe how the grassland would look in different seasons.

Describe the anticipated changes in colour and the condition of grasses: growing phase, flowering phase, dyeing phase, dry phase.

The grassland has great variations in moisture levels during different seasons, which determines the amount of grass available for the wild herbivores. The grassland ecosystem has a rapid productive growing phase during the monsoon, a fully grown winter phase and a very dry dormant summer phase in which the grass biomass above the ground is very low. The lives of the various grassland animals are closely linked to these seasonal variations. They put on weight and bring up their young soon after the monsoon when there is plenty of grass. All the grassland birds nest and bring up their young when there is plenty to eat. As insects also respond by breeding when there is more grass cover, birds are able to add protein to the diet of their young ones by feeding them with insects. The critical 'pinch period' for the animals of the grasslands is during summer months when both grass and water become scarce. This is a hard time for herbivores which results in serious loss of weight. The animals then anxiously await the next monsoon.

Box 3.3 Abundance of grassland species:

Try to count the number of grasshoppers that jump out of a 1sq.mt quadrant. Count at least 20 such quadrants. This is difficult. Repeat the count for ants, beetles etc. This is nearly impossible, as there are just too many insects. This will demonstrate to students the great abundance of insects in the grassland. Compare this to the much smaller number of birds and mammals that can be counted.

The semi-arid grassland ecosystem has a very large 'producer' base of grasses, herbs and thorny shrubs. This is utilised as food by the large number of herbivorous animals such as blackbuck, chinkara, hare, field mice and a great abundance of varied types of plant dependant insects. These animals use this energy for their day to day lives. The herbivorous animals are food for the carnivores such as the wolf, jackal, fox, several species of birds or prey, snakes and lizards.

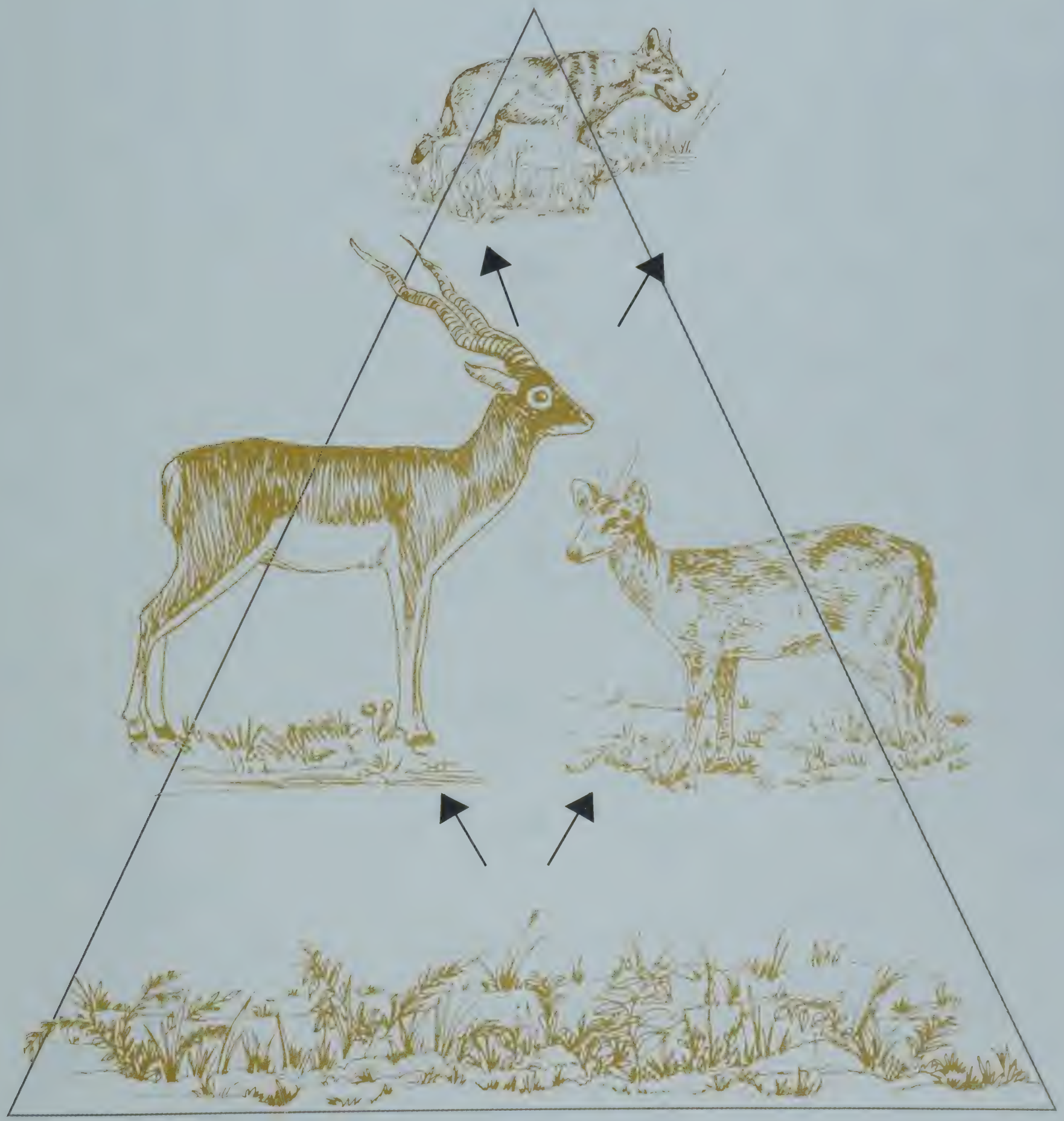
The grassland ecosystem is greatly influenced by the low local availability of the few sources of water such as ponds, streams, lakes and rivers. All the animals depend heavily on these limited watering places. Most animals such as blackbuck and chinkara drink only occasionally and are adapted for this life with very little water.

Box 3.4 Uses of grasslands:

Discuss with local people how they use the grasslands. They graze cattle, cut fodder, and collect fuelwood from the shrub cover.

FOOD PYRAMIDS IN GRASSLAND ECOSYSTEMS

SEMI-ARID GRASSLAND



ARID REGION GRASSLAND

MOIST GRASSLAND

Ecological cycles in grassland ecosystems

Nutrient cycle

The dry grass and the faeces of animals is broken down by insects, fungi and bacteria which recycle this dead organic material into simple inorganic nutrients that the grassland plants can absorb for their growth during the monsoon months.

Energy cycle

Energy from the sun is used by the grass for its growth. This biomass of vegetation supplies food for herbivorous animals. In the arid grasslands there are species such as the blackbuck and chinkara. They spend energy in their daily activities for their growth, respiration, metabolism, breeding, etc. They use energy for moving from one grazing area to another and to run away from predators. Thus a large quantum of grass must be produced to support all their activities. Much of this energy is lost during these activities. On these large herds of herbivores, only a few carnivores can survive. Predators spend energy during their metabolism, and digestion of food, for activities, while chasing their prey and breeding. This forms the grasslands energy pyramid, with a wide base of grasses, a smaller amount of herbivores and very few carnivores at the apex. Man is one of the apex species. If the grasslands food pyramid structure is disrupted the apex species cannot survive.

Box 3.5 Grassland carrying capacity:

Create an awareness of the enormous quantity of grass as against the number of herbivores dependent on it. This is the 'carrying capacity' of the grassland. Document how there are only occasional sightings of predators as compared to prey species.

The Flora

Among the various grassland types the semi-arid regions of India have the most extensive grasslands and scrublands. Each grassland area has its own species of grasses. In scrubland ecosystems the grass is dotted with shrubs or a few thorny trees such as Babul, Ber, Khair and Hiwar.

Some grasses and forbes are perennials and are present throughout the year. Other plants emerge only during the monsoon season and are called annuals. These die during the dry season and grow again during the monsoon from the seeds of the previous year that are widely scattered by the wind. Most species of grasses are pollinated and dispersed by wind. In many grass species the root remains dormant during the summer months and regrows during the monsoon.

The grasslands have a variety of flowering herbs. Each species usually flowers only for a few days. They are pollinated by insects and quickly develop seeds. The flowers disappear and every few days a new group of plants come into flower creating beautiful changes in colour as seen in the Himalayan region.

The Fauna

The animals of the grassland plains of India are highly threatened by human activity. This is due to the loss of their habitat, as grasslands have been converted to other uses as well as due to illegal *shikar*. The mammals such as antelopes are specifically adapted to grasslands. The grasslands also have specialised birds reptiles and insect life that do not live in other types of ecosystems such as forests or wetlands.

Mammals

The large herbivorous animals of grasslands usually live in herds. This is a protective mechanism. Each animal in the herd periodically keeps a lookout for predators in the open landscape. Thus as soon as one of the animals spots a carnivore it raises an alarm which makes the herd scatter in all directions. In the confusion that follows the predator which is unable to identify an individual to chase, frequently gets confused and gives up the chase. Thus carnivores have to make several unsuccessful charges before they catch their prey.

The Himalayan herbivores include the unique Hangul or Kashmir Stag, and several wild species of sheep and goats such as Thar and Goral.

The largest herbivore of the grasslands is the Indian elephant. It is found in the Terai and the hills of the southern part of the Western Ghats, Nilgiris and Annamalais in South India. It requires an enormous amount of tall grasses to feed on. When the grasses become dry in the summer months, the elephants live on bamboo and tree branches.

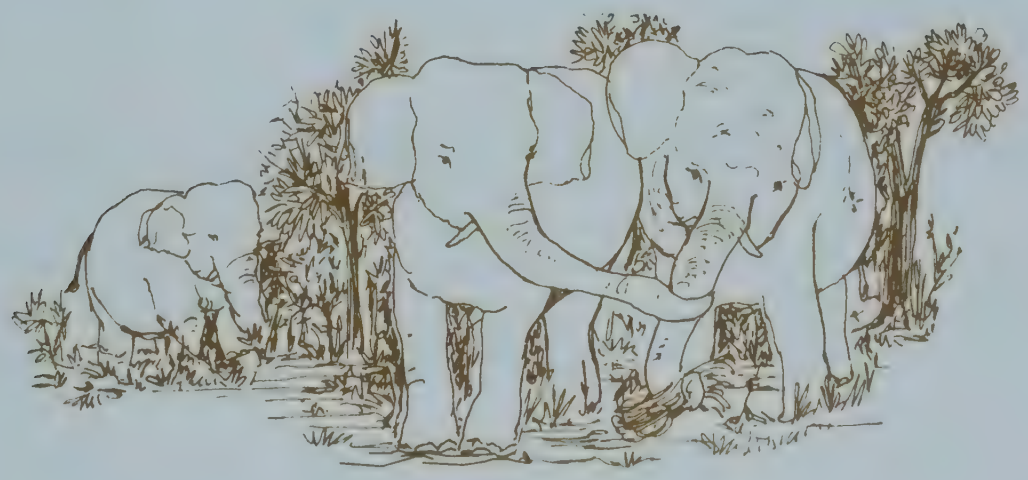
The other large grass dependent herbivores are the Gaur and the Wild buffalo. A deer species restricted to the Terai grasslands is the beautiful Swamp deer, which has 12 tines that branch out majestically on its great antlers.

The largest antelope like animal is the Nilgai or blue bull. Among the prominent herbivores of the semiarid grasslands is the beautiful Blackbuck antelope. This fleet footed animal lives in large herds in the wide open grassy plains of Rajasthan, Gujarat, Maharashtra, Karnataka and Tamil Nadu. The Chinkara, which is smaller than the Blackbuck, belongs to the Gazelle family and lives in small family groups. It favours the low scrub and grass covered hills of the Deccan rather than the flat open plains.

The grasslands form an ideal habitat for rodents such as hare, rats and mice. These are found in great abundance. Though they are small in size, as they are highly abundant, they consume enormous amounts of plant material.

The apex predator in the grassland ecosystem was the Cheetah, which is now extinct in India. At present the major predator of the fleet footed herbivores of the grassland is the wolf. This animal is threatened by extinction as it is frequently killed by shepherds. It has become increasingly dependant on sheep as its natural prey such as blackbuck have been severely reduced in numbers due to loss of their habitat as well as illegal shikar.

Some animals such as the Neelgai, Blackbuck and Chinkara are found only in India. These are called our endemic species. Blackbuck, which was once a common animal of the plains of India and occurred in thousands, is now only found in small patches of the residual grassland.



Birds

Several species of birds are adapted specially for living in the grassland ecosystem. Birds of prey of the grassland, such as eagles, falcons, kites and owls hunt for their food in the short grass. They feed on a large number of insects, lizards, snakes and rodents. These birds are at the apex of the food pyramid.

The over-use of pesticides used on crops enters the grassland food chain through the sprayed plant material which is eaten by insect pests. Through these plant dependant insects the insecticides are transferred to and concentrated in the bodies of insectivorous predators. As this toxic material affects a large number of insects and the rodents that feed on them, it is finally heavily concentrated in the few birds of prey that feed on rodents. The effect of these lethal chemicals is magnified through each level of the food chain. This leads to the death of these apex predators. As man is also at the apex of the food pyramid his health is seriously affected by the overuse of pesticides.

Box 3.6 Birdwatching in grasslands:

Make a checklist of common grassland birds by identifying them from the Book of Indian Birds by Salim Ali. Read what each species feeds on.

One of the most threatened bird species of the grasslands is the Great Indian Bustard. This bird has always been rare and is now under very serious threat. The Bustards lay only one egg every year on the ground. If the egg is destroyed or the chick is killed, the breeding season is unsuccessful in maintaining their small population. If intensive conservation measures are not taken this species is likely to become extinct. Some of the commonly seen grassland birds are partridges, quails and larks.

Reptiles

The common reptiles of this habitat are snakes such as the rat snake and lizards such as the common garden calotes and the flat skinks, which are commonly called snake lizard. The Sitana lizard has a brightly colored skin flap under its neck. It uses this to demonstrate its presence and establish the right to its own territory.

Insects

Insects especially ants and beetles are the most abundant group of animals found in grassland ecosystems. Ant colonies can consist of thousands of ants. Some species such as butterflies, moths, ants and beetles have an important role in the grassland ecosystem as only a specific insect is essential for pollinating certain plants. Others such as harvester ants spread seeds of the grasses. Several species of insects form a major source of food for insectivorous reptiles and birds.

Box 3.7 Observing the insect world:

Observe how the ants live and collect food. Observe how beetles behave in the grassland.

Grasshoppers, locusts, praying mantis and stick insets are common grassland insects. Many types of spiders build their webs in the grass.

Box 3.8 Observe a spider catch its prey:

See the different types of webs. Tunnel web spiders make a tunnel and sit inside waiting for prey, which are pulled in and eaten.

A large part of plant material of the grasslands is used as food by the millions of insects that live in this special community. Grassland insects form a major source of food for insectivorous birds and reptiles. Thus there are thousands of plants and animals that are linked to each other through prey and predator relationships.

Box 3.9 Documenting animal behaviour:

Let the students make a general list of behavioural patterns of all the animals, birds and insects they see. What are they doing. How and where did they find them in the grass? What is their relationship to the grassland as a habitat?

Box 3.10 Understanding grassland food chains:

Identify as many plant and animal species and use the list to form as many food chains as possible.

How are grasslands used?

Grasslands are the grazing areas of many rural communities. Farmers who keep cattle or goats, as well as shepherds who keep sheep, are highly dependent on grasslands. Domestic animals are grazed in the 'common' land of the village. Fodder is collected and stored to feed cattle when there is no grass left for them to graze in summer. Grass is also used to thatch houses and farm sheds. The thorny bushes and branches of the few trees that are seen in grasslands are used as a major source of fuelwood.

Box 3.11 Mapping landuse in grasslands:

Near a village make a landscape map showing where the cattle are sent for grazing and for water. Where do people collect fuelwood?

What are the threats to grassland ecosystems?

In many areas grasslands have been used for centuries by pastoral communities. Overutilization and changes in landuse of the 'common grazing lands' of rural communities has lead to their degradation. The grassland cover in the country in terms of permanent pastures now covers only 3.7 percent of land. A major threat to natural grasslands is the conversion of grasslands into irrigated farmlands. In the Deccan, irrigated farms are mainly used to grow sugarcane. After heavy watering such land becomes saline and useless in a few years. More recently many of these grassland tracts have been converted into industrial areas.

Grasslands have a limited ability to support domestic animals and wildlife. Increasing this pressure by increasing the number of domestic animals reduces the 'naturalness' of the grassland ecosystem leading to its degradation.

Most grassland ecosystems are highly modified by human activities. Cattle, sheep and goat grazing, and lighting repeated fires affects grasslands adversely. Changing the grasslands to other forms of landuse such as agriculture, tree plantations and industrialisation forms a serious threat to this highly productive ecosystem. Thus some of the grassland patches which are in a less disturbed state and have retained their special plants and animals need to be urgently protected.

Degradation of grasslands due to over grazing by cattle, sheep and goats occurs if more than a certain number of animals are present in the grasslands. When animals overgraze the area, the grasses are converted into flat stubs with very little green matter. Degraded grasslands have fewer grass species as the nutritious species are entirely used up by the large number of domestic animals. They are thus unable to regenerate.

When fires are lit in the grasslands in summer, the burnt grass gets a fresh flush of small green shoots which the domestic animals graze on. If this is done too frequently the grasslands begin to deteriorate. Finally grasslands become bare, the soil is solidly compacted by trampling, or is washed away during the monsoon by rain and whipped into dust storms during the hot dry summer. The land is degraded, as there is no grass to hold the soil in place. It becomes a wasteland.

Box 3.12 Documenting grassland degradation:

Document if there has been a change in landuse patterns during the last few decades by asking local rural people. Observe protected and degraded areas.

Why are our grassland species vanishing?

Most people feel that it is only our forests and its wildlife that is disappearing. However, other natural ecosystems such as grasslands are disappearing even more rapidly.

Many of the grassland species have disappeared from several parts of India in which they were found 50 or 60 years ago. The Cheetah is extinct in India. The Wolf is now highly threatened. Blackbuck and chinkara are poached for meat. Unless grassland species are protected they will vanish from their shrinking habitat, as natural and undisturbed grasslands are found in very few locations. If these animals and birds are killed or their habitat is reduced further, their extinction will rapidly follow.

What if our grasslands vanish?

If our grasslands are lost we will lose a highly specialised ecosystem in which plants and animals have been adapted to these habitat conditions over millions of years.

The extinction of species is a great loss to Mankind. The genes of wild grasses is extremely useful for developing new crop varieties. New medicines could also be discovered from wild grassland plants. It is possible that genes from wild herbivores such as wild sheep, goats and antelopes may be used for developing new strains of domestic animals.

How can grassland ecosystems be conserved?

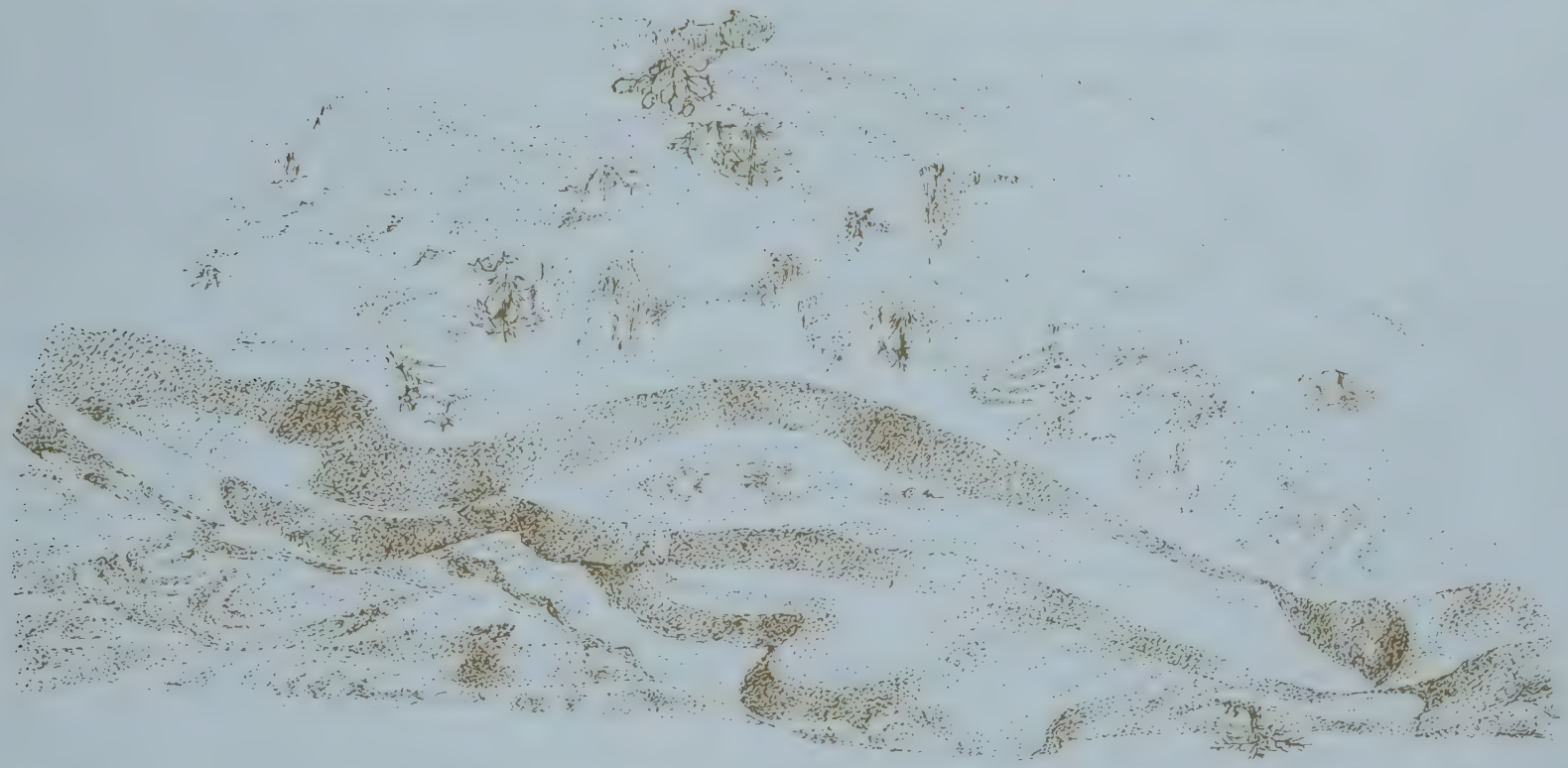
Grasslands should not be overgrazed and areas of the grasslands should be closed for grazing. It is better to collect grass for stall feeding cattle. Parts of the grassland must be closed every year so that a rotational grazing pattern is established. Fires must be prevented and rapidly controlled. In hilly areas soil and water management in each micro-catchment helps grasslands to return to a natural highly productive ecosystem.

To protect the most natural undisturbed grassland ecosystems, Sanctuaries and National Parks must be created. Their management should focus on preserving all their unique species of plants and animals. Thus they should not be converted into plantations of trees. The open grassland is the habitat of its specialised fauna. Planting trees in these areas reduces the natural features of this ecosystem resulting in the destruction of this unique habitat for wildlife.

What should we do?

- There is a need to preserve the few natural grassland areas that still survive by creating National Parks and Wildlife Sanctuaries in all the different types of grasslands.
- Animals such as the wolf, blackbuck, chinkara and birds such as bustards and floricans have now become rare all over the country. They must be carefully protected in the few National Parks and Wildlife Sanctuaries that have natural grassland habitats as well as outside these protected areas.
- We need to create an awareness among people that grasslands are of great value. If we are all concerned about our disappearing grasslands and their wonderful wildlife, the Government will be motivated to protect them.
- Keeping grasslands alive is a National priority.

4. THE DESERT AND SEMI-ARID ECOSYSTEM



Desert and semi arid lands are highly specialised and sensitive ecosystems that are easily destroyed by human activities. The species of these dry areas can live only in this specialised habitat.

What is a desert or a semiarid ecosystem?

Deserts and semi arid areas are located in Western India and the Deccan Plateau. The climate in these vast tracts is extremely dry. There are also cold deserts such as in Ladakh, which are located in the high plateaus of the Himalayas. The most typical desert landscape that is seen in Rajasthan is in the Thar Desert. This has sand dunes. There are also areas covered with sparse grasses and a few shrubs, which grow if it rains. In most areas of the Thar the rainfall is scanty and sporadic. In an area it may rain only once every few years. In the adjoining semi arid tract the vegetation consists of a few shrubs and thorny trees such as kher and babul.

The Great and Little Rann of Kutch are highly specialised arid ecosystems. In the summers they are similar to a desert landscape. However as these are low-lying areas near the sea, they get converted to salt marshes during the monsoons. During this period they attract an enormous number of aquatic birds such as ducks, geese, cranes, storks, etc. The Great Rann is famous, as it is the only known breeding colony of the Greater and Lesser Flamingos in our country. The Little Rann of Kutch is the only home of the wild in India.

Ecological cycles in desert and semi arid ecosystems

The ecological cycles are all linked to the extreme lack of water in these areas. There is very little precipitation of rain and high levels of evaporation due to the scorching high temperatures. The lack of water seriously limits plant growth. Thus there are few herbivores as compared to a forest or grassland and extremely few carnivores as the prey base is small. The nutrient flow is limited and there is very little detritus for recycling.

Box 4.1 Observing desert and semi-arid landscapes:

Observe the sparse but specialised nature of vegetation in a desert, semi arid landscape. Document the number of animal species that are seen in the vicinity. There are very few compared with other types of ecosystems.

Desert and Semiarid land species

There are several species that are specially evolved to live in this arid tract. Their population is usually limited, as the vegetation base is sparse. Most of these animals can survive even if there is very little water.

The mammals include caracal, desert fox, hedgehog, gerbil, blackbuck and chinkara. All these animals are specially adapted to living in this very harsh environment. Many are threatened by the loss of their habitat.

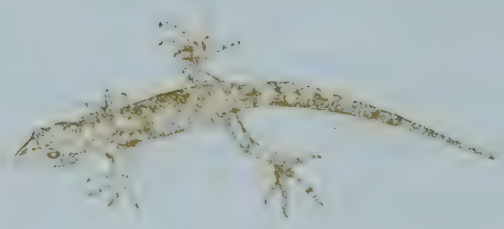
The important rare and threatened bird species are the Great Indian Bustard, the florican and various birds of prey. Sandgrouse, partridges, quails and larks are some of the common species of this ecosystem though they also live in grasslands.

Reptiles include star tortoise, monitor lizard and other lizards and snakes that have adapted to the desert. The star tortoise is extensively used in the pet trade and is highly threatened.

Insects such as dung beetles, grasshoppers and ants are frequently met with in the desert ecosystem.

Great Indian Bustard

Grasshopper



Lizard

Box 4.2 Observing the fauna of semi arid country:

Identify the birds and insects which are most easily seen. Students can document how each species is using its habitat. What is do these species feed on in this harsh environment?

Sandgrouse

Hare

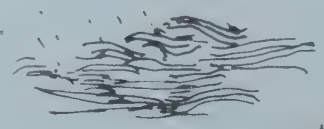
Partridge

How are desert and semiarid ecosystems used?

Areas of scanty vegetation with semiarid scrubland have been used for camel, cattle and goat grazing in Rajasthan and Gujarat, and for sheep grazing in the Deccan Plateau.

Areas that have a little moisture, such as along the watercourses, have been used for growing crops such as jowar, and bajra. The natural grasses and local varieties of crops have adapted to growing at very low moisture levels. These can be used for genetic engineering and developing arid land crops for the future.

Box 4.3 Mapping land and water resources:



Document the pattern of landuse and the great importance of the meagre water resources in this ecosystem. Observe that all the animals aggregate around the limited supply of water.

What are the threats to desert ecosystems?

Several types of development strategies as well as human population growth have begun to affect the natural ecosystem of the desert and semi arid land. Conversion of these lands through extensive irrigation systems has changed several of the natural characteristics of this region. The canal water evaporates rapidly bringing the salts to the surface. The region becomes highly unproductive as it becomes saline. Pulling excessive groudwater from tube wells lowers the water table creating an even drier environment. Thus human activities destroy the naturalness of this unique ecosystem. The special species evolved here over millions of years may soon become extinct.

How can desert ecosystems be conserved?

Desert ecosystems are extremely sensitive. Their ecological balance that forms a habitat for their plants and animals is easily disturbed. Desert people have traditionally protected their meagre water resources. The Bishnois in Rajasthan are known to have protected their Khejdi trees and the blackbuck antelope for several generations. The tradition began when the ruler of their region ordered his army to cut down trees for his own use. Several Bishnois were said to have been killed while trying to protect their trees.

There is an urgent need to protect residual patches of this ecosystem within National Parks and Wildlife Sanctuaries in desert and semi arid areas. The Indira Gandhi Canal in Rajasthan is destroying this important natural arid ecosystem, as it will convert the region into intensive agriculture. In Kutch areas of the little Rann, which is the only home of the Wild Ass will be destroyed by the spread of salt works.

Development Projects alter the desert and arid landscape. There is a sharp reduction in the habitat available for its specialised species bringing them to the verge of extinction. We need a sustainable form of development that takes the special needs of the desert into account.

5. AQUATIC SYSTEMS

Water is an important factor in all our ecosystems. Several ecosystems exist in fresh and salt water. There is very little fresh water on earth, which is a key resource for people all over the world.

What is an aquatic ecosystem?

In aquatic ecosystems, plants and animals live in water. These species are adapted to live in different types of aquatic habitats. The special abiotic features are its physical aspects such as the quality of the water, which includes its clarity, salinity, oxygen content and rate of flow. Aquatic ecosystems may be classified as being **stagnant** ecosystems, or **running water** ecosystems. The mud gravel or rocks that form the bed of the aquatic ecosystem alter its characteristics and influence its plant and animal species composition. The aquatic ecosystems are classified into **freshwater**, **brackish** and **marine** ecosystems, which are based on the salinity levels.

The fresh water ecosystems that have running water are streams and rivers. Ponds, tanks and lakes are ecosystems where water does not flow. *Wetlands* are special ecosystems in which the water level fluctuates dramatically in different seasons. They have expanses of shallow water with aquatic vegetation, which forms an ideal habitat for fish, crustacea and water birds.

Marine ecosystems are highly saline, while brackish areas have less saline water such as in river deltas. *Coral reefs* are very rich in species and are found in only a few shallow tropical seas. The richest coral reefs in India are around the Andaman and Nicobar islands and in the gulf of Kutch.

Brackish water ecosystems in river deltas are covered by mangrove forests and are among the world's most productive ecosystems in terms of biomass production. The largest mangrove swamps are in the Sunderbans in the delta of the Ganges.

Types of Aquatic ecosystems

Fresh water ecosystems			Marine ecosystems		
Flowing water		**Still water**	**Brackish water**		**Saline water**
Streams	Rivers	Ponds,Wetlands, Lakes	Deltas	Coastal shallows, Coral reefs	Deep ocean

Box 5.1 Documenting the nature of aquatic ecosystems:

Arrange a visit to an aquatic ecosystem such as a lake, river or seacoast.
Observe if the water is clean or polluted. A simple kit can be used to study water quality.

The Pond ecosystem

The pond is the simplest aquatic ecosystem to observe.

Box 5.2 Studies on the ecology of a pond:

Make observations on a seasonally active pond on several occasions before, during and after the monsoon. Document the seasonal changes in the plant and animal life.

There are differences in a pond that is temporary and has water only in the monsoon, and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by terrestrial plants for the rest of the year.

When a pond begins to fill during the rains, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they have remained dormant in the dry phase. Gradually more complex animals such as crabs frogs and fish return to the pond. The vegetation in the water consists of floating weeds and rooted vegetation on the periphery which grow on the muddy floor under water and emerge out of the surface of the water.

Box 5.3 The vegetation zones of a waters edge:

Observe the different zones of vegetation - grasses on the periphery, emergent reeds, floating vegetation and underwater plants in the pond.

As the pond fills in the monsoon a large number of food chains are formed. Algae is eaten by microscopic animals, which are in turn eaten by small fish on which larger carnivorous fish depend. These are in turn eaten by birds such as kingfishers herons and birds of prey. Aquatic insects, worms and snails feed on the waste material excreted by animals and the dead or decaying plant and animal matter. They act on the detritus, which is broken down into nutrients which aquatic plants can absorb, thus completing the nutrient cycle in the pond. The temporary ponds begin to dry after the rains and the surrounding grasses and terrestrial plants spread into the moist mud that is exposed. Animals such as frogs, snails and worms remain dormant in the mud, awaiting the next monsoon.

A Field Visit To A Pond

This is an exciting learning experience that represents and explains the basic functions that are seen in most other ecosystems in a simple way. A pond or tank can be identified near every village or town.

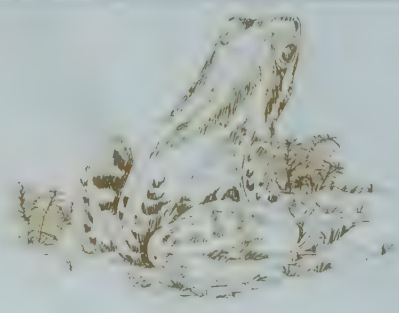
Box 5.4 Seasonal field observations on a pond:

Early stage - soon after the pond fills with water in the monsoon: Algae and microscopic animals.

Fully active phase: Submerged and emergent vegetation – fish, frogs, snails, worms and aquatic insects.

Shrinking phase: Drying aquatic plant life with dead and dying plant material and terrestrial plants growing on the exposed mud of the pond.

Dry phase: Overgrown with grasses and shrubs with hidden dormant animals in the mud, which cannot be seen.



Lake ecosystem

A lake ecosystem functions like a giant permanent pond. A large amount of its plant material is the algae, which derives energy from the sun. This is transferred to the microscopic animals, which feed on the algae. There are fish that are herbivorous and are dependent on algae and aquatic weeds. The small animals such as snails are used as food by small carnivorous fish, which in turn are eaten by larger carnivorous fish. Some specialised fish, such as catfish, feed on the detritus on the muddy bed of the lake.

Energy cycles through the lake ecosystem from the sunlight that penetrates the water surface to the plants. From plants to herbivorous animals and carnivores. Animals excrete waste products, which settle on the bottom of the lake. This is broken down by small animals that live in the mud in the floor of the lake. This acts as the nutrient material that is used by aquatic plants for their growth. During this process plants use Carbon from CO_2 for their growth and in the process release Oxygen. This Oxygen is then used by aquatic animals, which filter water through their respiratory system.

Box 5.5 Laboratory exploration:

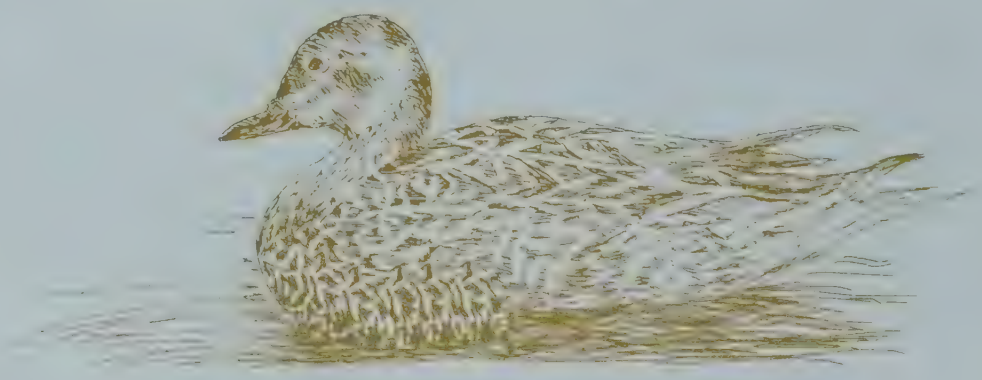
Observe water from the pond in a glass. Document its colour and what it contains.

Observe water from a pond under the microscope. There are a large number of algae and zooplank form the basic food chains of the aquatic ecosystem.

A Field Visit To A Lake

Box 5.6 Observations on a Lake ecosystem:

Document the way in which different water birds use the various habitats both on the shore and in the water. Each of the different species of aquatic birds shares its habitat with only a few other species. Each species specialises in certain types of food and feeds at different depths.



Box 5.7 Observing what local people use the lake for:

They collect drinking water and use it for all their other domestic needs. They catch fish and crabs, graze their cattle and buffaloes in or near the water. They lift water from the lake by pumps to irrigate their fields.

Stream and River ecosystems

Streams and rivers are flowing water ecosystems in which all the living forms are specially adapted to different rates of flow. Some plants and animals such as snails and other burrowing animals can withstand the rapid flow of the hill streams. Other species of plants and animals such as water beetles and skaters can live only in slower moving water. Some species of fish, such as Mahseer, go upstream from rivers to hill streams for breeding. They need crystal clear water to be able to breed. They lay eggs in clear water so that their young grow successfully.

As deforestation occurs in the hills the water in the streams that once flowed throughout the year become seasonal. This leads to flash floods in the rains and a shortage of water once the streams dry up after the monsoon.

The community of flora and fauna of streams and rivers depends on the clarity, flow and oxygen content as well as the nature of their beds. The stream or river can have a sandy, rocky or muddy bed, each type having its own species of plants and animals.

Box 5.8 Diversity and abundance of life:

Make a checklist of all the visible aquatic flora and fauna. Identify those that are most abundant. Observe and document the food chains. Estimate or count the population (abundance) of different species observed in the aquatic ecosystem.

A field Visit To a River

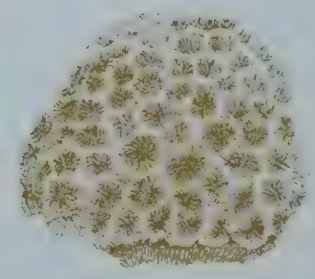
This can be organised so that on the same visit students can observe differences between a clean unpolluted stretch of river and a dirty polluted stretch of river water.

Box 5.9 Field observations on a river front:

Observe a clean stretch of river in a wilderness area. The water is clear and full of life. In its many pools fish dart about. Tadpoles swim around and crabs crawl along the bottom of the water.
Observe a river in an urban area, the water cannot be used for drinking as it is dirty. See the water in a glass – it is coloured – can we drink it! 'Who has polluted it and how?' This is a sign of unsustainable use of water, which is a vital life giving resource.
Fresh water is being rapidly reduced on earth. Once water is polluted in a river someone else has to use this dirty water downstream. This can spread waterborne diseases to downstream towns and villages.
In a rural area observe all the different ways in which people use the water from a stream or a river.
In a forest observe all the different animal tracks at the edge of the water. All wildlife depends on this resource for their day-to-day survival.

The riverbank can be in a city, town, village, agricultural or industrial area. It provides water to the people living on the bank and in many situations must also act as a passage for wastewater discharge. This waste must be purified before it can be discharged into the river. It is important to explain how this process is carried out.

The Marine Ecosystem



The Indian Ocean, the Arabian Sea and the Bay of Bengal constitute the marine ecosystems around peninsular India. In the coastal area the sea is shallow while further away, it is deep. Both these are different ecosystems. The producers in this ecosystem vary from microscopic algae to large seaweeds. There are millions of zooplankton and a large variety of invertebrates on which live fish, turtles and marine mammals.

The shallow areas near Kutch and around the Andaman and Nicobar Islands are one of the most incredible coral reefs in the world. Coral reefs are only second to tropical evergreen forests in their richness of species. Fish, crustacea, starfish, jellyfish and the polyps that deposit the coral are a few of the thousands of species that form this incredible world under the shallow sea.

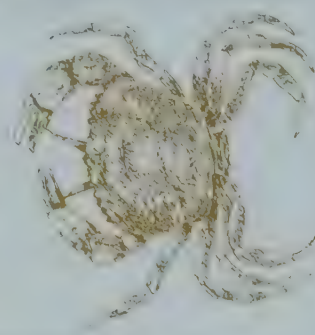
Deforestation of adjacent mangroves leads to silt being carried out to sea where it is deposited on the coral which then dies. There are many different types of coastal ecosystems which are highly dependent on the tide.

The marine ecosystem is used by coastal fisherfolk for fishing which forms their livelihood. In the past, fishing was done at a sustainable level. The marine ecosystem continued to maintain its abundant supply of fish over many generations. Now with intensive fishing by using giant nets and mechanised boats, fish catch in the Indian ocean has dropped significantly.

A field visit to a beach

Beaches can be sandy, rocky, shell covered or muddy. On each of these different types, there are several specific species which have evolved to occupy a separate niche. Observe all the different crustacea that make holes in the sand.
Observe how the various shore birds fed on their prey by probing into the shore.
Identify the different fish that the fishermen have caught. Ask if the fish catch has decreased, remained the same or increased during the last decade or two.

How aquatic ecosystems are used?



Man uses aquatic ecosystems for the clean freshwater on which his life is completely dependent. We need clean water to drink and for other domestic uses. Water is essential for agriculture. Fisherfolk use the aquatic ecosystem to earn a livelihood. People catch fish and crabs. They collect edible plants. This is used locally as food or for sale in the market. Over fishing leads to a serious decline in the catch and a long-term loss of income for fisherfolk.

Box 5.10 Resource use:

Observe the different types of fish caught by fishermen.

Marshes and wetlands are of great economic importance for people who live on their fish, crustacea, reeds, grasses and other produce.

Modern man impounds water in dams to be able to store it throughout the year. Agriculture and industry are highly dependent on large quantities of water. However this leads to problems for tribal people who have lived there before the dams were built as they are displaced to build large dams. These dams make rich people richer in the farmland and supports people in large urban centres that use enormous quantities of water. The poor tribal folk become even poorer as the natural resources they depend on are taken away as their lands are submerged under the water of the dam.

Dams are built across rivers to generate electricity. A large proportion of this energy is used by urban people, by agriculturists in irrigated farmlands and in enormous quantities for industry. Large dams have serious ill effects on natural river ecosystems. While water from dams used for irrigation has lead to economic prosperity in some areas, in semiarid areas that are artificially irrigated the high level of evaporation leads to severe salinisation as salts are brought up into the surface layers of the soil. This makes such lands gradually more and more saline and unproductive.

Box 5.11 Water – the greatest of all resources:

What do you use water for during the course of one day?
How much do you use? Can you stop wasting water by using it carefully?
How can you reduce the water you use for bathing and other uses?
Discuss how waste water can be used in the garden.
How can it be recycled?

What are the threats to aquatic ecosystems?

Water pollution occurs from sewage and poorly managed solid waste in urban areas when it enters the aquatic ecosystem of lakes and rivers. This leads to a process called eutrophication, which destroys life in the water as the oxygen content is severely reduced. Fish and crustacea cannot breath and are killed. A foul odour is produced. Gradually the natural flora and fauna of the aquatic ecosystem is destroyed.

In rural areas the excessive use of fertilisers causes an increase in nutrients, which leads to eutrophication. Pesticides used in adjacent fields pollute water and kills off its aquatic animals. Chemical pollution from industry kills a large number of life forms in adjacent aquatic ecosystems. Contamination by heavy metals and other toxic chemicals affects the health of people who live near these areas as they depend on this water.

How can aquatic ecosystems be conserved?

For sustainable use of an aquatic ecosystem, water pollution must be prevented. It does not make sense to allow water to be polluted and then try to clean it up.

Changing the nature of the aquatic ecosystem from a flowing water ecosystem to a static ecosystem destroys its natural biological diversity. Thus dams across rivers decrease the population of species that require running water, while favouring those that need standing water.

Aquatic ecosystems, especially wetlands, need protection by including them in Sanctuaries or National Parks in the same way in which we protect natural forests. These sanctuaries protect a variety of forms of life as well as rare fish which are now highly endangered such as the Mahseer. Wetland Sanctuaries and National Parks are of greatest importance as this is one of the most threatened of our ecosystems. As the proportion of the earth's surface that is naturally covered by wetlands is very small compared to forests or grasslands, the wetland ecosystem is very highly threatened.

Box 5.12 What to 'do' in a wetland sanctuary:

Arrange a visit to a Wetland Sanctuary. Observe the varied vegetation zones within the ecosystem. Map the plants as terrestrial, emergent, floating or underwater. Students can develop maps of the aquatic ecosystem vegetation and its relationship to species of aquatic birds. Observe how the system is utilized and document these assets - fish, crustacea, reeds, plants used as food.

Observe in contrast a polluted body of water. Only the more robust species remain while the more sensitive disappear.

Just enjoy the feeling of being with nature. Appreciate the beauty of natural vegetation. Thrill at watching wild species of animals and birds without disturbing them in their aquatic habitat.

INTERACTIVE LEARNING FOR STUDENTS FROM NATURE

Present textbooks of Science and Geography contain several statements on ecosystems without clearly explaining to a student how they are integral to our lives. The teacher will have to link the topics covered in this Handbook to the relevant lessons in the textbook.

One cannot expect each student to be given an opportunity to visit all the different ecological systems. The teacher must appreciate the Biogeographic region in which the school is situated and the neighbourhood ecosystems that can be visited so that students curiosity about their surroundings can be stimulated. Teachers can then ask them to 'discover your world'. While this must remain fun and produce a love for nature, it must be clearly linked to curricula, if it is to be taken seriously. Teachers are able to do this effectively if they make an attempt to observe the natural history of the ecosystem they plan to visit with students well in advance. An appreciation of the local biogeography helps in defining what to look for in the field. Try not to ask students to memorise long lists of names of different species. Instead bring about a greater understanding of the behaviour and linkages of the species observed to their habitat. Ask them to discover for themselves what is happening in the ecosystem. Apart from knowledge, a sense of the wonder of nature is what the teacher must bring home to students during field observations.

Just let students enjoy being in nature. It is the greatest of all teachers.

Further reading

For a deeper understanding, use the following educational material:

1. Bharucha EK, 2002. The Biodiversity of India CD ROM. Mapin Publishing, Ahmedabad.
2. Ali S, 1992. The Book of Indian Birds. 11th Edition. BNHS, Oxford University Press.
3. Prater SH, 1993. The Book of Indian Animals. BNHS, Oxford University Press.
4. Bole PV and Y Vaghani, 1986. Field Guide to the Common Trees of India. WWF-I, Oxford University Press.
5. Blatter E and WS Millard, 1993. Some Beautiful Indian Trees. BNHS, Oxford University Press.

Using these as field guides is a valuable tool to the appreciation of India's ecosystems.

The Bharati Vidyapeeth is an educational institution that has over a hundred teaching institutions spread over Western Maharashtra in both urban and rural areas. The Bharati Vidyapeeth Institute of Environment Education and Research (BVIEER) established on 25th January 1994 is a part of the Bharati Vidyapeeth Deemed University, Pune.

The programs of the Institute include formal environment education, non-formal educational activities and research. These independent spheres of activities have been integrated to augment the effectiveness of all three components. In the formal sector the Institute conducts a Doctoral program, a Masters program and an undergraduate program in Environment Science as well as a Diploma in Environment Education specially designed for inservice school teachers and individuals working with Government or Non-Government organizations who deal with environmental issues. The Institute has a major non-formal environment education outreach initiative which includes conducting training workshops for teachers in environment education, organizing school environment education programs through trained teachers and developing locale specific environment education material. The Institute also houses an Environment Museum and Activity Centre, which is used by teachers and students as a teaching-learning resource. The research done at the Institute focuses on need based issues with a view to bring about proconservation action. A major focus is on biodiversity conservation and environment education

ICEF

The India-Canada Environment Facility (ICEF) was established in 1993 following the signing of a Memorandum of Understanding (MOU) between the Government of India and the Government of Canada in 1992.

It is a joint project of the two Governments for the purpose of undertaking environmental projects in the water and energy sectors. ICEF operates as a registered society under the Indian Societies registration Act 1860. It is jointly managed by representatives from the Governments of India and Canada. The partnership works directly with Indian institutions and organisations to enhance and promote environmentally sound development, with a principal focus on building and sustaining institutional capacity and related management capability in natural resource and environmental management. The objectives of ICEF are institutional development, conservation and restoration, policy and national dialogue and technology adoption.

WWF

The World Wide Fund for Nature-India (WWF-India) formerly known as the World Wildlife Fund-India was established in 1969 as a Charitable trust under the Bombay Public trusts Act 1950.

Today WWF-India is the country's largest conservation NGO with a network of State/ Divisional and Field Offices spread across the country with its Secretariat located in New Delhi. WWF's mission is 'The promotion of nature conservation and environmental protection as the basis for sustainable and equitable development'. In achieving its mission WWF uses field programs that serve as demonstration projects, public policy analysis and debates through independent research, consultation, campaigns, education activities for key target groups including the youth, professionals and administrators, networking and supporting the work of fellow NGOs in India and mobilizing necessary financial, scientific and technical resources.

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